TAMPEREEN TEKNILLINEN YLIOPISTO
TAMPERE UNIVERSITY OF TECHNOLOGY

MINNA LEIVO

# EFFECTS OF DEMAND RESPONSE PRODUCTS IN THE INTERFACE OF ELECTRICITY SUPPLIER AND CUSTOMER

Master of Science Thesis

Examiner: Professor Pertti Järventausta
Examiner and topic approved by the Council of the Faculty of Computing and Electrical Engineering on 4th June 2014

# ABSTRACT

**MINNA LEIVO**: Effects of demand response products in the interface of electricity supplier and customer
Tampere University of Technology
Master of Science Thesis, 74 pages, 7 Appendix pages
December 2014
Master's Degree Program in Electrical Engineering
Major: Alternative Electrical Energy Technologies
Examiner: Professor Pertti Järventausta

Keywords: demand response, smart grid, electricity market, electricity contract, information systems, households, customer interface

The increasing amount of intermittent renewable energy production sets new challenges for the power system and electricity market. In price-based demand response (DR) the electricity consumption is shifted from the more expensive spot hours to the cheaper hours when there is more production. If the supplier can influence the customers' consumption the flexibility could benefit the whole electricity market and the use of production capacity can be optimized.

Under research of this study was what kind of electricity contracts are needed to commit households to DR and how those contracts would affect the interface of supplier and the customer. Central questions were how the customer would time his consumption as the supplier wishes or how supplier's load control could be compensated to the customer if the supplier can control e.g. customer's heating. Electricity market information exchange and legislation were examined to enable new DR contract processes. Representatives of electricity supply companies were interviewed to find out their opinions and expectations about DR.

The field of energy business is widely regulated which sets certain limits for the electricity sale and new kind of electricity contracts. As a result of this study was found out that updating these terms and decrees can also promote DR because no party will invest on needed infrastructure without incentives or obligations.

As a result of the interviews was found out that suppliers are interested in DR if volatility of electricity price increases making it profitable. Also after that the interviewees wished for as ready service as possible to adopt DR and which is easy to implement for different customers. It can be concluded that suppliers' and distribution system operators' information systems and electricity market information exchange need new functionalities, e.g. to load management. Possible load control has to be implemented keeping the supplier switching process easy.

Suitable customers need to find the DR products so that DR would benefit the supplier. The new basis for electricity pricing has to be introduced to the customers. At first, dynamically priced electricity contract is the easiest way to implement DR so the product should be priced to benefit both the supplier and the customer. Marketing of the product can be proceed by increasing consumers' awareness of electricity price formation and offering alternative incentives. The image of future's electricity supplier could become diverse energy service provider.

# TIIVISTELMÄ

**MINNA LEIVO**: Kysyntäjoustotuotteiden vaikutukset sähkön myyjän ja asiakkaan rajapinnassa
Tampereen teknillinen yliopisto
Diplomityö, 74 sivua, 7 liitesivua
Joulukuu 2014
Sähkötekniikan koulutusohjelma
Pääaine: Vaihtoehtoiset sähköenergiateknologiat
Tarkastaja: professori Pertti Järventausta

Avainsanat: kysyntäjousto, älykäs sähköverkko, sähkömarkkinat, sähkösopimus, tietojärjestelmät, kotitaloudet, asiakasrajapinta

Uusiutuvan sääriippuvan energiantuotannon lisääntyminen asettaa haasteita sähkövoimajärjestelmälle ja sähkömarkkinoille. Hintaperusteisessa kysyntäjoustossa sähkönkulutusta siirretään huipputunneilta halvemmille tunneille, jolloin tuotantoa on enemmän. Jos sähkönmyyjä voi vaikuttaa asiakkaiden sähkönkulutukseen, voisi kulutusjousto hyödyttää koko sähkömarkkinoita ja optimoida tuotantokapasiteetin käytön.

Tässä työssä tutkittiin, millaisilla sähkösopimuksilla kotitalousasiakkaat saataisiin mukaan kysyntäjoustoon, ja miten uudet sähkösopimukset vaikuttavat sähkönmyyjän ja asiakkaan rajapintaan. Keskeisiä kysymyksiä oli, millaisilla kannustimilla myyjä saisi asiakkaan joustamaan halutulla tavalla, tai minkälaisella hyvitysmekanismilla myyjä saisi ohjata asiakkaan kulutusta, esimerkiksi lämmitystä. Työssä myös tarkasteltiin kuinka hyvin sähkömarkkinoiden tiedonvaihto sekä lainsäädäntö palvelevat uusien sähkösopimusten tarpeita. Sähkönmyyntiyhtiöiden edustajien näkemyksiä ja toiveita selvitettiin haastatteluilla.

Energia-alan liiketoiminta on laajalti säädeltyä, mikä asettaa rajoituksia sähkönmyynnille ja uuden tyyppisille sopimuksille. Työn tuloksina selvisi, että päivittämällä näitä säädöksiä voidaan kuitenkin myös edistää kysyntäjouston yleistymistä, sillä mikään taho ei panosta tarvittavan infrastruktuurin rakentamiseen ilman kannustimia tai velvoitteita.

Haastattelujen tuloksina selvisi, että kysyntäjousto kiinnostaa sähkönmyyjiä, jos hintapiikit yleistyvät ja tekevät siitä kannattavaa. Senkin jälkeen haastatellut toivoivat kulutusjouston hyödyntämiseen mahdollisimman valmista ratkaisua, joka palvelee erityyppisiä asiakkaita ja on helppo ottaa käyttöön. Tästä voidaan todeta, että myyjien ja verkkoyhtiöiden tietojärjestelmät sekä sähkömarkkinoiden tiedonvaihto tarvitsevat uusia toiminnallisuuksia esimerkiksi kulutuksen hallintaan. Mahdolliset kuormanohjaukset on toteutettava siten, että asiakkaan on helppo vaihtaa sähkönmyyjää.

Jotta sähkönmyyjä hyötyy kysyntäjoustosta, tarvitsee sopivien asiakkaiden löytää uudet sopimustuotteet. Näinollen tarve uudenlaiselle sähkön hinnoittelulle on tehtävä asiakkaille tutuksi. Aluksi dynaamisesti hinnoiteltu sähkösopimus on helpoin tapa toteuttaa kysyntäjoustoa, joten siitä kannattaa hinnoitella tuote, joka hyödyttää sekä myyjää että asiakasta. Markkinointia edesauttaa asiakkaiden tietämyksen lisääminen sähkön hinnan muodostumisesta, vaihtoehtoisten kannustimien tarjoaminen sekä mielikuvan muuttaminen sähkön myyjästä, joka voisi olla tulevaisuudessa monipuolinen energiapalveluiden tarjoaja.

## PREFACE

The topic for this thesis was provided by Empower IM Oy and it is related to SGEM program. The examiner for this thesis was Professor Pertti Järventausta from Tampere University of Technology. As a supervisor from Empower IM was M.Sc. Joni Aalto.

I am grateful to get this interesting and actual topic to grow my knowledge about smart grid and electricity market. I want to thank Joni for providing me this topic and offering valuable material and guidance during the work. I also want to thank Pertti for examining this thesis and giving constructive feedback.

Thanks for support during the work to my friends, family, colleagues and family of Tamppikuja. Thanks to my university for awesome possibilities to prepare myself to step into the business life. Thanks to Skilta for unforgettable years of student life and to Remmi-Team for all the glamour and victory. Thanks to M.Sc. Maria for proofreading, and thanks to her, Hennu and Sanna for our quality time. Special thanks to innovative expert Heidi for discussions about electricity market. The most I want to thank my Dad for being a great model of Master of Science in Electrical Engineering.

Tampere, December 16th, 2014

Minna Leivo

# TABLE OF CONTENTS

# TERMS AND DEFINITIONS

| | |
|---|---|
| AMR | Automatic Meter Reading |
| BRP | Balance Responsible Party |
| DR | Demand Response |
| DSO | Distribution System Operator |
| HEMS | Home Energy Management System |
| OTC | Over the Counter |
| TSO | Transmission System Operator |

| | |
|---|---|
| Aggregator | A new party in the electricity market. Combines smaller consumption or production units into bigger combination that can participate in different markets and carry out load control. |
| Customer | An end-user, including households and small scale entrepreneur customers who do not operate as a party in electricity markets. |
| Elbas | Nordic intraday electricity market. |
| Elspot | Nordic day-ahead electricity market. |
| Elspot FIN | Price for exchange electricity in Finnish price area. |
| ENTSO-E | European Network of Transmission System Operators for Electricity. An association collaborating for emergence of the internal electricity market within the European Union. |
| Nord Pool | Scandinavian power exchange. Nord Pool Spot AS offers both day-ahead and intraday markets for electrical energy. |
| NordREG | Organisation for the Nordic energy regulators. Promotes the development of a common Nordic electricity end user market. |
| SGEM | Smart Grids and Energy Markets, Finnish national research project. |
| Supplier | Energy company selling electricity to customers. Also retailer. |

# 1. INTRODUCTION

## 1.1 Background for demand response

Increasing amount of intermittent energy production requires changes in consumption habit of electricity. Demand response is an economical and energy efficient way to control power balance as the electricity consumption has to equal to production all the time. Energy policy of the European Union encourages to increase the renewable production, which increases the volatility of electricity production. If the electricity production is dependent on the weather and therefore cannot be controlled, the consumption has to be more flexible.

Compared to other commodities or currency traded in exchange the volatility of electricity price is multiple. However, in Finland the price for the electricity is rather low compared to other countries. The volatility of hourly price is relative small, as the level of intermittent renewable energy production, like wind and solar power, is pretty low. Therefore, there is not great interest towards demand response (DR) yet. The thesis discusses DR in the framework of Finnish energy industry. Finland is a good example case since Nordic electricity market is specially advanced common electricity market place in the world. Anyway, the DR products and ideas can be applied to other electricity markets as well.

The target of demand response and load management is to shift demand from on-peak to off-peak times. In price based DR the electricity consumption is shifted from the more expensive spot hours to the cheaper hours. Controllable loads move to different point in time but total used energy remains the same. For example, water heating, room heating and cooling are suitable loads to increase flexibility in consumption. They can be consumed any time and their total energy consumption is not dependent on the time when it is consumed.

This far, DR has been utilized with bigger industrial customers. If the industry process of a company can be easily controlled, it is beneficial for both the company and the electricity supplier to interrupt the process during high spot prices. Different tariff for day and night-time energy is also one kind of DR. In Finland, a significant amount of households warm up their homes with cheaper energy during nights, which is also beneficial for the whole energy market. In this study, the focus is in the household customers. Controlling the loads is not totally new even for the consumers, because before the distribution system operator (DSO) has been able to restrict the consumption in case of technical reason or critical power shortage.

DR can be utilized in electricity supply business for profit optimization in spot market, balance management, balance power market and reserve market. DR can provide great savings especially in balance market where the energy price can easily rise high. In order to bring the most benefit for the whole system and electricity market, DR capacity should be used in day-ahead Elspot market, because there the actions will affect the price formation process. In the main scope of this study is Elspot market so further in this study DR refers to that if not referred others. The figure 1.1 illustrates DR and shifting of the consumption during a day.

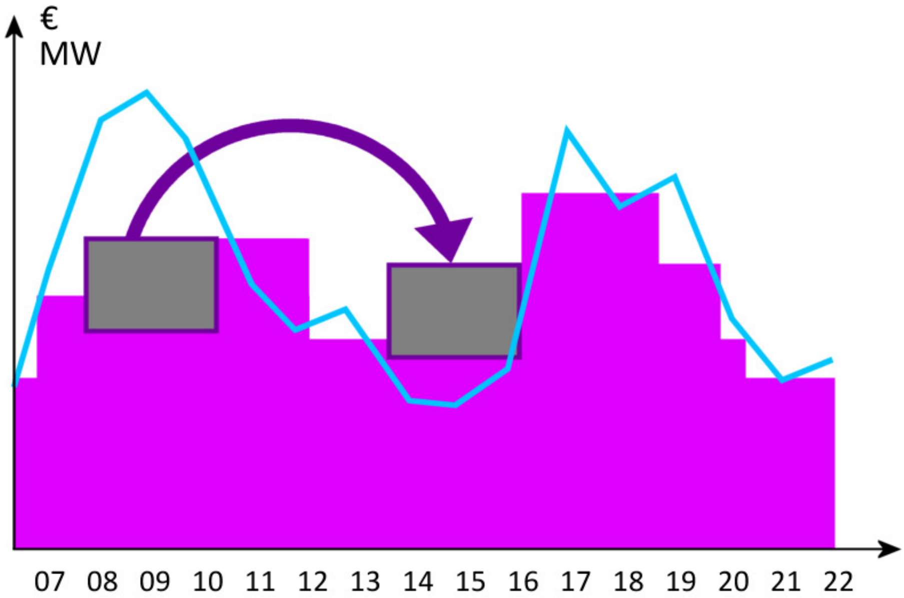


***Figure 1.1**. Demand response will shift the consumption. The blue line is electricity price.*

DR is not interesting or useful for electricity supplier until the controllable mass is large enough. Therefore it is important to find the loads the supplier could control and what kind of control groups it could build from the customers' loads. The goal of this thesis is to come up with propositions for future's electricity contracts and how they offer incentives for the end-user to be flexible with his consumption.

## 1.2 Challenges in the framework

The customers can change their energy consumption voluntary if their electricity usage is priced based on the spot price (indirect control). Another option is load management made by the supplier, if customers' electricity contract allows the supplier to control their loads (direct control). An easiest example to execute load control is market price based control of reserving electric heating. DR is usually regarded as cutting the consumption but it can be realised also by increasing the production or sometimes also increasing the consumption. The customers can also have own electricity production that has to be taken into account in load management.

*Government decree about electricity metering* has pushed DSOs to equip electricity usage places with remotely readable AMR meters that enable hour specific metering of electricity consumption (Government decree 2009). These meters build a base for DR because only hourly metered consumption enables invoicing with dynamic electricity price. Depending on the couplings, simple DR is possible to carry out with these present AMR meters by controlling the load connected behind a relay of the meter. More advanced load control requires a Home Energy Management System (HEMS). HEMS is a system that enables the customer or the supplier control and optimize the electricity consumption by managing the loads as needed. This study will not take a stance on the device executing the load control. To control several load groups, a more complicated controlling is needed. In practice, this means multiple relays in the usage place. The households using night-time tariff have their heating loads already connected behind the relay of the AMR meter. This existing control with only one coupling offers already significant DR potential.

One central issue to solve is how to get customer committed to DR. With dynamically priced electricity contract customer will control his consumption voluntary if there exist expensive hourly prices enough. However, this kind of active customer sets challenges for supplier's balance management. This is the reason why the suppliers would like to get the right to affect customers' consumption as it is most profitable for them. In this case the compensation for the customer can be paid based on a fixed-price contract, or based on how many times his loads has been under supplier's control. The options for contract structures are compared in chapter *6.2 Alternatives for electricity contract*. To make it possible to measure and invoice electricity consumption in future's smart grid environment some updates are needed in the present electricity market information exchange and to the information systems of electricity market parties. These new requirements will be reviewed in chapter *6.3 Information in concluding of contract and during supply*.

## 1.3 Contribution of this study

This thesis discusses on DR product implementation in the interface of electricity supplier and end-user. The purpose is to find alternatives for new kind of electricity contracts that include incentives for the end-users to be flexible with their consumption. Furthermore, the focus is to compare how the DR contract process will differ from the traditional signing of electricity contract. Increased amount of information about the usage place equipment and contract conditions need to be stored in supplier's information systems, which will be discussed as well. The electricity market information exchange need to be able to handle load control requests sent between different market parties. Roles of different parties cross in the framework of DR, which sets challenges in finding solutions that benefit all the stakeholders.

This study is based on the development work of Empower IM Oy being a part of the Finnish national research project *Smart Grids and Energy Markets* (SGEM). The project has been funded by Tekes, the Finnish Funding Agency for Technology and Innovation. SGEM is a research program coordinated by Cleen Oy for developing international smart grid solutions that can be demonstrated in a real environment utilizing Finnish R&D infrastructure. The aim is to create innovative solutions for future's energy industry and electricity market focusing on power distribution and its interfaces. The five year SGEM program will come to end in the beginning of year 2015. The different studies related to SGEM have delivered solutions for energy efficiency, to minimize $CO_2$ emissions, to increase grid reliability and activate the role of small customers. This study is related to SGEM's DR theme and work package *4 Active customer*. (SGEM, 2013)

Empower IM Oy is one division of Finnish Empower corporation. The business of Empower IM consist of offering services for energy market, developing smart grid solutions and providing IT systems for energy sector. Electricity supplier companies are a significant customer segment for Empower IM. The role of Empower IM is to enable the implementation of the new electricity contracts and DR products into present systems and processes.

The thesis begins with the discussion about electricity market in general to get an overview of the environment where the need for DR rises from. Chapter 3 speaks out the electricity contracts and processes in the interface between a supplier and a customer giving some examples of electricity contracts nowadays. Those contracts and processes will be reviewed from the DR point of view in chapter 6. The chapter will give suggestions for future's electricity contracts, review the present framework from the legislation point of view and introduce new ways to create additional value to both the supplier and customer. As reference for these ideas are other SGEM reports, scientific articles, fresh publications, researches and examples about DR and smart grid. A few customers of Empower IM were interviewed to find out how they see the development of the framework and the potential customer flexibility. The findings from the interviews are presented in chapter 5.

# 2. SUPPLIER IN THE ELECTRICITY MARKET

This chapter introduces the structure of the Nordic electricity market. In general, electricity market includes electricity production, exchange, transmission, distribution and retail. Electricity production and trade are free businesses and do not need a concession whereas regulated electricity distribution has remained its natural monopoly in its operating area. Those businesses have to be divided. In Finland the mechanism of electricity market is regulated by Electricity Market Act (588/2013), Government decree based on Electricity Market Act (65/2009), Energy Authority and decrees and directives of European Union. (Partanen & al. 2011), (Energy Authority 2014a)

The electricity energy markets can be divided in a wholesale market and a retail market. Electricity can be bought and sold also outside of these markets directly between the producer and consumer in Over-the-Counter market (OTC). (Partanen & al. 2011) As the target in this thesis is the interface between the customer and electricity supplier the discussion leaves out the OTC market where contracts handle relatively great amount of energy.

Energy retail business for the supplier is minimizing the electricity procurement costs and selling electricity with a profitable price. The supplier purchases its electricity from the wholesale market or produces part of it by itself. The sales margin is small in the retail market and the volatility of electricity price in the wholesale market is high, which rises the operational risks. Risk management and planning of electricity purchase are important in the business field because volatility of electricity price is multiple compared to currency or share markets. Demand response can be used as a tool to hedge electricity procurement in short-term profit optimization and this will be discussed in chapter *4.2.2 Demand response for the supplier*. (Valtonen & al. 2012)

Firstly, this chapter clarifies the basics of electricity market introducing the Nordic electricity exchange Nord Pool. Balance management is characteristic for electricity trade business because the consumption has to be equal to the production all the time. From the overall market description the discussion moves to balance management and information exchange in the electricity market. The last sub-section discusses the significant lines that have been decided to be applied in Nordic electricity market in the near future. Supplier centric model, Nordic Balance Settlement and datahub will all contribute the introduction of DR.

## 2.1 Electricity market mechanism

Electricity producers, retailers and large electricity users buy and sell electricity on the exchange. Finland belongs to the common market area of the electricity exchange Nord Pool with Denmark, Norway, Sweden, Estonia, Lithuania and Latvia. For the end-user the electricity price consist of electricity purchase, the cost of transmission and taxes. For a household customer around the third of total costs comes from electric energy. However, the majority of that energy cost goes for the energy producer and the marginal of the supplier stays small. Later in this study, when writing about electricity price it always means the price of energy if not referred otherwise. The diagram in figure 2.1 describes the energy price formation. (Partanen & al. 2011)

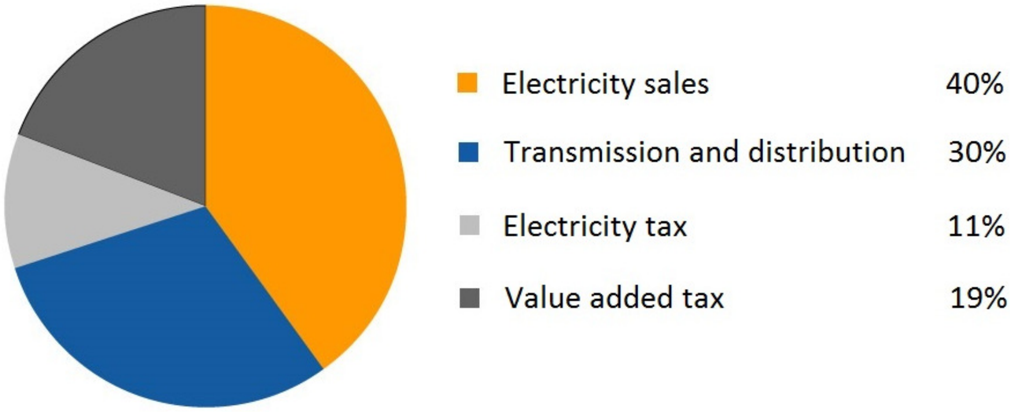


***Figure 2.1**. The formation of electricity price for a household customer. (Vattenfall 2014a)*

The large common market area makes the electricity production more efficient, because e.g. the advantageous weather conditions can be widely utilized. To get the most out of the common market the physical transmission connection has to be sufficient between the countries to transmit for example all the overproduction of hydro power from Norway to Finland. Although Finland is connected to neighbor countries with several cables to enable international transmission there sometimes occur situations when the transmission capacity is not enough. These bottlenecks restrict transmission between the grids, which furthermore disturbs the market. Short-term bottlenecks in the transmission grid are taken care of commercially by means of counter trading, but long-term bottlenecks build different price areas within the exchange area. The area prices differ from the system price and they are used when the cheaply produced electricity cannot be transmitted to the more expensive area because of the bottlenecks. Finland is an own price area but for example Sweden is divided in four price areas. (Fingrid 2014a)

### 2.1.1 Finland as part of Nord Pool

The Nordic countries are forerunners with their common wholesale market Nord Pool. The wholesale electricity price (system price) is determined hourly based on the balance of demand and supply in the common market. Every morning the market members post their sale and purchase orders to the auction for the coming day. On this day-ahead market, which is called Elspot in Nord Pool, each order specifies the electricity volume in MWh/h that a member is willing to buy or sell at specific price levels (€/MWh) for each individual hour in the following day. When the noon deadline for members to submit bids has passed, all purchase and sell orders are aggregated into two curves for each delivery hour showing the demand and supply, see figure 2.2. (Nord Pool 2014)


***Figure 2.2.*** *The spot price is determined by intersection of sale and purchase offers. (Nord Pool 2014)*

The spot price formed in the exchange will not affect the general customer in a short time span because the majority of their electricity contracts are valid indefinitely or for a fixed term with a constant price. There the electricity supplier carries the price risk. When examining the spot prices in longer time span the evaluation of the price trend will shift to the end-users' contract prices too. However, electricity contracts based on the spot price are becoming more common and planned DR contracts will utilize the cheaper spot hours. This will be explained in chapter *3.2 Present electricity contract*.

The spot price is formed on the day-ahead market, but the trading of electricity continues on intra-day market, called Elbas in Nord Pool. The Elbas market acts as an after-market place for the day-ahead market Elspot. The Elbas market is open for trading every day 24 hours and the continuous market covers the Nordic countries, Germany and Estonia. Suppliers can make bids to buy or sell multiples of 1 MW after the spot prices for the hours next day are revealed, and the balancing trades can be done until one hour prior to the delivery. (Partanen & al. 2011)

In spot market the electricity price forms only for the coming day. Many companies want to know their energy costs for a longer time and with financial contracts the electricity price can be hedged for up to six years. Trading in spot market leads to actual delivery of electricity but there is no physical delivery for financial power market contracts. In the Nordic region financial contracts like futures and forwards are traded through Nasdaq OMX Commodities. The system price calculated by Nord Pool Spot is used as the reference price for the financial market. (Nord Pool 2014)

Although the electricity exchange in Nordic countries is common, all the countries have their own Transmission System Operator (TSO). The Finnish TSO Fingrid is by majority owned by the Finnish government and it manages the national transmission grid. It is the open supplier for the balance responsible parties (BRPs) in Finland and manages the nation-wide system balance in cooperation with other Nordic transmission companies. (Similä & al. 2011)

### 2.1.2 EU and the future potential

The European Union is aiming to a unified electricity market. On the unified electricity market the energy will be purchased where it is the cheapest. The advantage of larger electricity market district is the possibility to produce energy there where it is most economic and less harmful for the environment at any moment.

For example on sunny days in Germany photovoltaic systems are producing surplus energy. Due to the mismatch of sunshine hours and residential electricity consumption households have difficulties using more than 35% of their rooftop electricity production for their own needs, unless they make supplementary investments (Schleicher-Tappeser 2012). However, the storage of electricity has its challenges since the batteries are large and expensive and energy transformation increases always losses. The unified electricity market in Europe would make it possible to transfer the surplus energy somewhere where the weather is not as optimal to produce renewable energy. Then, for example, the cloudy Finland could enjoy the cheap electricity from Germany. Additionally, Germany is forecasted to be the only country in EU where the total load will decrease in the coming years. Its renewable energy production will correspondingly increase because of the decision to close its all nuclear power plants till year 2022. In Scenario EU 2020 Germany is expected to be the biggest producer in both wind and solar power. (Entso-E 2012)

ENTSO-E, European Network of Transmission System Operators for Electricity, is preparing laws and guidelines to unify the European electricity market. In general, the varied electricity market mechanisms in EU are far away from Nord Pool. For example, bottlenecks hinder the development of the unified European electricity market. (Entso-E 2012) The North West Europe has approached Nord Pool with the implementation of day-ahead market coupling in Europe. There is still way to go with the intraday market to reach Nord Pool's Elbas market. Coupling national intraday markets is significant to let the market players to benefit of increasing integration of renewable energy sources. ENTSO-E's *Network Code on Capacity Allocation and Congestion Management* defines the rules for a continuous intraday market that allows market participants to trade up electricity to at least one hour before real-time. (Entso-E 2014)

## 2.2 Balance management

Electricity has the particularity that it cannot be widely stored at any moment. Consequently, there must be a balance between production and consumption all the time. Balance management indicates the maintenance of power balance between electricity generation and consumption. This section focus on the balance management on the level of Finland.

Balance settlement unit Fingrid is responsible for the national balance management in Finland. The main function with balance management is to maintain the power balance at every moment by keeping the frequency of the electricity system within allowed limits: the frequency can vary between 49,9 and 50,1 Hz. The frequency describes the balance between electricity supply and demand. If production goes over the consumption it rises the frequency over 50 Hz. Correspondingly, if consumption goes over production, the frequency becomes lower than 50 Hz. (Partanen & al. 2011)

According to Finnish law a supplier in electricity market is responsible for its balance management. A supplier has to cover its electricity usage and sale with electricity production and purchase agreements within one balance settlement period. (Electricity market act 2013)

An open supplier takes responsible for smaller parties' balance management. It compensates the difference between predicted and realized electricity consumption and production. After a definition in *Electricity market procedural instructions*, an open supplier is

*"a supplier providing the customer with all the electricity it needs or balancing the differences between the customer's electricity generation and acquisition and between consumption and supply by supplying the missing amount of electricity or receiving the surplus electricity during each hour."*

Besides physical balance management the financial balance settlement has to be done separately. There the balance settlement unit calculates how much electricity has been used during every hour and by which party, i.e. how much every party will be invoiced. (Partanen & al. 2011)

Government decree based on Electricity Market Act tells to make the balance settlement by hour. The DSO has to report the electricity deliveries counted in balance settlement for the suppliers to generate the bills and to fulfill their balance responsibility. There are several balance responsible parties (BRP) in the electricity market in Finland and uppermost in the balance responsible parties' chain is TSO Fingrid. A typical BRP is an energy company which works also as a supplier, but all the suppliers are not interested in working as a BRP. Every market party has an open supplier that balances their electricity supply and generation, and Fingrid is the open supplier for the BRPs. The hierarchy of balance settlement in Finland can be seen in figure 2.3 where electricity suppliers take place in the market party ellipses. A common Nordic balance settlement unit is under investigation and that will be discussed in chapter *2.2.3 Nordic Balance Settlement*. (Government decree 2009)

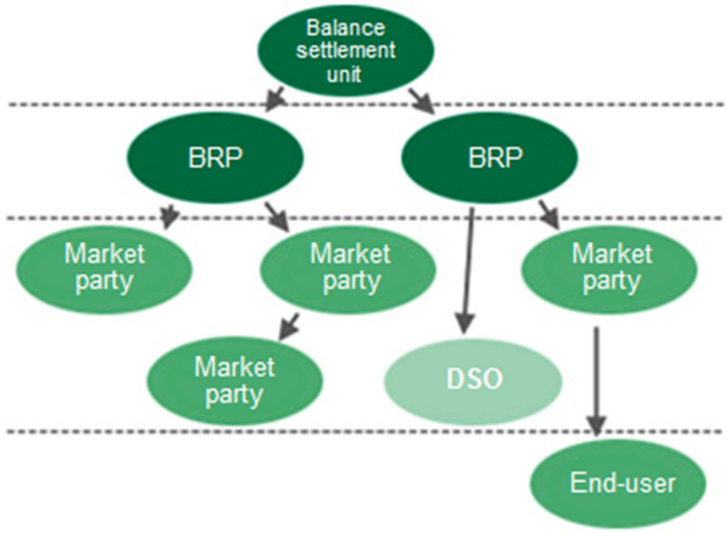


***Figure 2.3***. *The balance responsibility chain. (Fingrid 2014b)*

When the power balance needs up- or down-regulation the power difference will be bought from regulating power market. All the market parties with capacity that can be regulated (production and consumption) can make regulating bids to the regulating power market maintained by Fingrid. The minimum capacity of one bid is 10 MW and the bid has to contain the power (MW) and price (€/MWh). Fingrid maintains the balancing power market because it does not have enough regulating capacity of its own to maintain the power balance. Nowadays balance management is divided into production balance and consumption balance and the BRP's balances cannot be netted. BRP's consumption balance consists of the BRP's total production plan (binding announcement), fixed transactions, and actual consumption. With DR can be influenced to the consumption balance. (Fingrid 2014b)

When utilizing DR there will be less need for regulating power, which brings financial advantage for the supplier. Nevertheless, even with DR the balance management plays a great role in the supplier's business and risk management. The better the consumption can be estimated the lower the price and volume risk becomes and, furthermore, a more stable income can be expected. The figure 2.4 describes the iterative balance management process made by the supplier.

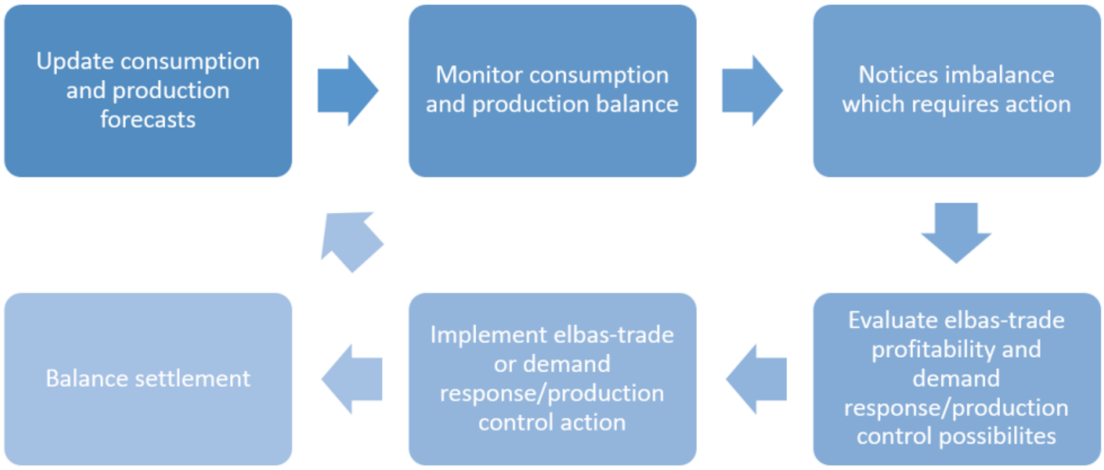


***Figure 2.4.*** *Electricity supplier's balance management process. (Aalto & al. 2014)*

## 2.3 Information exchange

In order to transmit the electricity from the power plant to the end-user the process requires cooperation from several parties. Electricity market needs well-functioning information exchange to enable communication between stakeholders on technical and financial level. The communication is based on message exchange made in EDIEL format. For example, when a metering point gets a new supplier, the supplier informs the DSO about the contract. Therefore, DSO can calculate the balance settlement to the suppliers with the information based on the messages.

When transmitting information concerning the customer, metering point and contract information between the electricity market parties is used PRODAT (product data) message exchange. This partly automated and directed information exchange consist mainly of time series information and it is transmitted in compliance with the EDIEL procedures. Beside this customer and usage place information message exchange there are different message groups: for example MSCONS message exchange is used for balance management. (Finnish Energy Industries 2014a)

The EDIEL procedure is the electricity industry's message and information exchange specification, developed by the Nordic Ediel Forum and it is based on EDIFACT-standards. The electricity supplier receives messages from distribution system operators (DSO) and balance responsible parties (BRP). The party sending the message is responsible for the sent information until it receives an acknowledgement message, APERAK. The APERAK message sends the information that message is either accepted or returns a reason why the original PRODAT message was erroneous. When sending these messages the market parties have to follow the procedural instructions which are based on the Electricity Market Act and the decrees and decisions of the Government and the Ministry of Employment and the Economy. (Energy Authority 2014)

A PRODAT message consists of header information (e.g. message type), parties (e.g. sender) and object (e.g. contract start date). These messages are sent for example in case of change of supplier, delivery contract closure, change of meter or information of move which tells the message type, e.g. Z03. (Nordic Ediel Forum 2012) Figure 2.5 shows the messages sent between different market parties in case of changing the supplier. As an example, message clarification for the message Z03 will be found in appendix A.

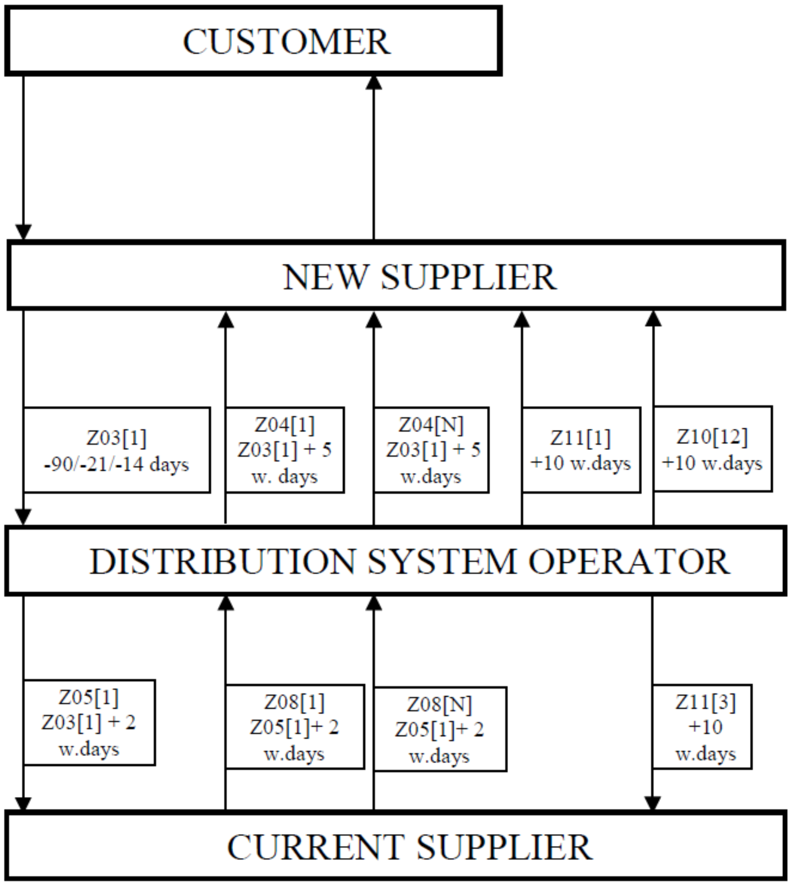


***Figure 2.5.*** *Information exchange messages in case of changing the supplier. (Finnish Energy Industries 2014a)*

All the parties in the electricity market have to ensure a safe and fluent information exchange between the market parties. The PRODAT messages are forwarded through a message operator, and there are three working operators in Finland: Sonera, Enfo and Empower IM. A new supplier on the market concludes a contract with one of the operators. Empower IM offers a test environment for testing the message exchange, and the procedural instructions obligate the suppliers to test the messages to fulfil the standards before starting the retail. Furthermore, all participants in the electricity market must have their own party ID to ensure the unequivocal information exchange. When a new supplier comes to market, the party ID is granted by TSO Fingrid. (Finnish Energy Industries 2011, 2013a)

The extra requirements for information exchange to enable handling of DR products will be discussed in chapter N.N. In the long run, the information exchange will change from EDIEL messages to XML-format when moving towards datahub and Nordic Balance Settlement. More about the situation in future will be discussed in the next section *2.4 Future aspects*.

## 2.4 Future aspects

This section describes the central concepts affecting on future's electricity market and will help the demand response to generalize. The concepts introduced in the following sub-sections are at this point under investigation. Working groups are doing research for supplier centric model, datahub and Nordic Balance Settlement (NBS) to implement those in Nordic electricity market in the near future. All these developments on the business field would make it easier to implement DR because they will make the communication and information exchange simpler. To create the needed value, DR affects many actors and it requires cooperation with different market parties in the electricity market.

### 2.4.1 Supplier centric model

The supplier has strong opportunities and economic interests towards DR because the sale business of electricity is open for competition. Therefore the supplier seems to be the best choice to carry out DR. In supplier centric model the electricity bill including the energy and the transmission fees will be sent for the customer on the same bill by the supplier. The customer will see the supplier as the central electricity market party.

In 2013 GAIA Consulting Oy made an analysis for NordREG on payment methods and ways to deal with risks in a Nordic market with mandatory combined billing. The analysis showed clearly that the supplier centric model where the customer is invoiced the total claim by the supplier and where the customer is in debt only to the supplier is the preferred choice. (NordREG 2014)

For example, this supplier centric model is used already in Germany, France and UK. Despite the customers have only a contractual relation with the supplier the DSO is not totally invisible for the customer. The customers need to contact the DSO in issues related to connections and electricity quality. (Annala & al. 2009)

In Finland, the electricity sales market opened for competition in 1995 and until that all the customers bought electricity from the local supplier who also owned the grid at that time. Then the same company naturally took care of the billing for both the energy and the transmission. Nowadays the local supplier is usually the supplier with a delivery obligation on that area. The customers who have not put their electricity sales out to tender have the electricity sales contract with the supplier with a delivery obligation which is defined in *Electricity market procedural instructions* as follows:

*"If a supplier is in a dominant market position within the area of responsibility of the distribution system operator to which the metering point belongs, and the metering point is equipped with main fuses of 3x63 amperes at maximum or whose metering point receives no more than 100,000 kWh of electricity per annum, the supplier has a delivery obligation to the user in accordance with section 21 of the Electricity Market Act."*

In Finland, there is a possibility to combined billing if the electricity contract is made with the so-called local supplier. Also, a few suppliers offer their customers a possibility to a combined bill regardless of customers' DSO. In these cases the combined bills may have been offered because some customers have considered separate bills as a barrier to switching the supplier. Yet there is no commonly agreed structures for the network service fees so the combined billing with other than the local DSO requires lots of work, which can be expensive and often has to be done manually. Combined billing would therefore require some common decisions for the network fees which are nowadays build individually in every DSO for every type of their customers. (Annala & al. 2009)

### 2.4.2 Datahub

Nowadays, the information exchange moves between several parties but the present complicated message exchange model is planned to centralize to travel through one datahub. The hub will make the information exchange easier in the future's electricity market because communication is needed only through one interface. The present information exchange as explained in chapter *2.3 Information exchange* through the three operators is illustrated in figure 2.6. The simplified information interface through one hub lies under that.

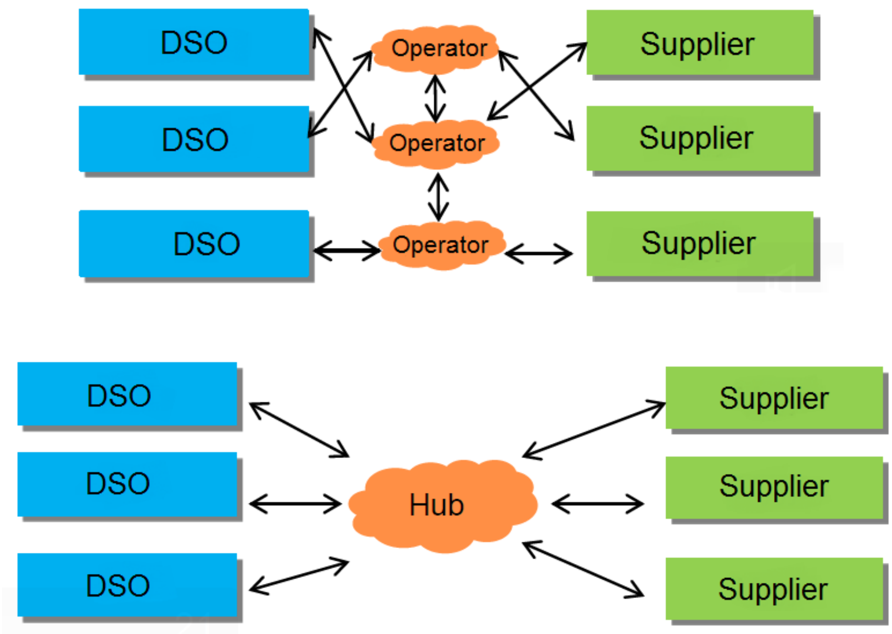


***Figure 2.6.**. Information exchange now and in the future through a datahub. (Finnish Energy Industries 2013b)*

The national centralized information exchange (datahub) will be regulated and the responsibility will be given to one party which is the national transmission grid Fingrid in Finland's case. The centralized database will include information like hourly metering data, electricity usage place, contract and customer information. All the parties deliver the information into datahub where the information is immediately accessible for another party. (Finnish Energy Industries 2013b)

For the supplier the hub can be seen to be divided in four functional modules: a web portal for a customer, customer relationship management, billing (including collecting) and metering data. Most important with these structures is that the interfaces need to be standardized. (Finnish Energy Industries 2013b)

The self-service web portal for the customer can be a competitive advance for the electricity supplier if the contract, billing, moving and other processes are made easily accessible and comfortable to use. There could be also an alternative where a customer reports what kind of equipment he has in his usage place. If the supplier gets the information about customer's load, battery and production capacities through the portal can this information be used when planning the DR operation. The customer could maybe update his expected energy consumption for the next hours and days in the portal.

The datahub, newly named as Helmer, will renovate the information exchange in the whole business area. For example, the message exchange will no more base on PRODAT messages as presented in chapter *2.3 Information exchange*. Updating the message exchange protocol is needed also to move towards common Nordic balance settlement which will be presented in the next sub-chapter.

### 2.4.3 Nordic Balance Settlement

Nordic Balance Settlement (NBS) is one feature of future's unified electricity market. The balance settlement is a natural monopoly and yet it is separate in all Nordic countries. Later, having a one and only balance settlement unit in Nord Pool it will lower the operational costs of imbalance settlement and make the related costs more transparent. In 2010 three Nordic TSOs, Fingrid, Svenska Kraftnät and Statnett, agreed to establish a harmonised imbalance settlement model (NBS) for Finland, Sweden and Norway. (NBS 2014)

A new Imbalance Settlement Responsible (ISR) eSett Oy has been founded to perform imbalance settlement and to invoice balancing services. ESett Oy is a company owned equally by Fingrid, Svenska Kraftnät and Statnett and this Nordic company is again a forerunner on its field in electricity market. It is regarded as an important step towards a fully functional common end-user market in Europe. The operational activities will be centralized for eSett but the national TSOs stay in juridical responsible for balance settlement. (NBS 2014)

According to NBS (2014) the reporting schedules need to be unified in all the three countries. In NBS imbalance settlement and related invoicing will both be performed on a weekly basis instead of the Finnish present one month cycle. Furthermore, NBS suggests that the information exchange between market parties and TSOs will be harmonized. There is need for new common message formats for reporting balance settlement information between the parties and eSett (ISR).

Under Nordic Ediel Group (NEG) operates a working group called NEMM (Nordic Energy Market Model for data exchange) which develops the information exchange on electricity market. It has published a plan about message formats for reporting the balance settlement. The plan suggests XML for the best choice for NBS message syntax instead of the previous EDIFACT syntax. As NBS requires anyway changes to all systems changing the syntax becomes only a small additional cost. The Danish Datahub shows example and has already implemented XML documents based on ENTSO-E standards. The possible protocol for communication would be SMTP which is used in Norway and Sweden instead of present FTP in Finland. (eSett 2014)

When designing DR products for customers the implementation should be done with the restrictions and possibilities of the coming NBS. Though the NBS defines the information exchange in the first case between the supplier and the ISR the new syntaxes and protocols affect also the message exchange in the customer interface when the new datahub will be put to use.

# 3. INTERFACE BETWEEN SUPPLIER AND CUSTOMER

This chapter describes the present framework for electricity contracts taking the legislation and processes in electricity market into focus. Real examples of different electricity contracts are the best way to cover the function of the contracts nowadays. Those examples are a good starting point to develop future DR contracts too.

Declaring the present framework in this chapter gives the basis for opportunities and restrictions set by the legislation and procedural instructions for DR product implementation visions. This study will return to these facts in chapter 6 when considering if all the information needed in DR products is possible to collect when concluding the contracts and transmit with the processes. The legislation and restrictions vary in different countries, so Finland is taken as an example. Regardless, the business area is strictly regulated everywhere so the laws and decrees have to be surveyed carefully when implementing new electricity contracts.

## 3.1 Legislation in Finland and electricity metering

In Finland the mechanism of electricity market is regulated by Electricity Market Act (588/2013), Government decree based on Electricity Market Act (65/2009), Energy Authority and decrees and directives of European Union. (Energy Authority 2014a)

Based on Electricity Market Act, important restricting documents accepted by Finnish Energy Industries for the framework of this study are *Terms of Electricity Sales*, *Electricity market procedural instructions*, *Message exchange procedural instructions* and *Guideline for AMR metering*. The parts affecting the electricity contracts and DR will be pointed out in this chapter. Along with these there are plenty of other instructions set by the authorities, e.g. *Terms of Network Service* and *Terms of Network Connection for Electricity Generation*.

A regulation by Energy Authority about *Reporting the Authority on Retailer's Electricity Sales Terms and Price*s involves the supplier to inform about the common retail prices for the end-users and other electricity users whose usage place has the maximum size of 3x63 A main fuses or whose yearly consumption is maximum 100 MWh. The report has to include information if the price is valid indefinitely or for a fixed term or if it follows the spot price. If the terms of the contract differ significantly from the common terms of electricity sales, they have to be pointed out too. (Energy Authority 2014b)

According to Energy Market Act the connection contract has to be a written agreement but electricity sale contract can also be concluded spoken. If the sale contract is not concluded in writing, the supplier shall within two weeks from the conclusion of the contract send a contract confirmation to the customer. The contract concluded by the supplier and the customer is either valid indefinitely or for a fixed term.

Before the electricity usage was metered with meter that only measured the cumulative consumption and the meter had to be read once a year. The monthly invoicing was based on load profile curves and electricity suppliers also planned their electricity purchase based on those curves. Among the *Government decree about electricity metering* (2009), at least 80% of the electricity usage places have been equipped with remotely readable AMR meters from the beginning of 2014. The meter has to measure the hourly consumption and the DSO is responsible for installing the devices and sending the measured data for market parties.

The same Government decree (2009) gives the DSO supplementary responsibilities. When offering the metering service the DSO has to intend to support the customer to save electricity, to use it efficiently and to utilize the steering opportunities. The AMR meter has to be able to receive, apply and forward load steering orders. If the customer specially orders an AMR device with standardized coupling that enables real-time-monitoring of electricity consumption and a connection for a possible HEMS system the DSO is obligated to provide that kind of device. The day after the electricity delivery the DSO has to deliver the metering data to the supplier, and for the customer as well about his own usage place. In practice, the data is given for the customer through an online portal.

As pointed out in the *Guideline for AMR metering* (Finnish Energy Industries 2010) and in the energy service law the electricity retailer has to give a report for its customers about their own electricity consumption once a year. The report has to include comparison data about other customers from the same user type group. More about the requirements for the metering devices concerning the load control will be discussed in chapter *4.4 Load control*.

## 3.2 Present electricity contract

The customer buys electricity by making an electricity sale contract with any supplier in Finland. The customers who have not put their electricity sale out to tender have the electricity sale contract with the supplier with a delivery obligation. In that case, the contract is usually a total supply contract and the supplier invoices the power network service too. The supplier agrees on the provision of network service with the DSO. Those who do not buy electricity from the local supplier conclude separate network contract and sale contract for their metering point. (Finnish Energy Industries 2014a)

As declared in *Electricity market procedural instructions*, the electricity supply contract includes the network service which covers the electricity distribution. If the customer concludes only a sale contract, the supplier will arrange the network service contract for the customer as well with the DSO of the customer’s network area. Even though the supplier makes the network contract for the customer, the customer and the DSO are the contracting parties in the agreement.

When designing new electricity contracts it has to be taken into account that Energy Authority has given rules for reporting the contract prices (Energy Authority 2014b) to list them equally on the web site, www.sahkonhinta.fi. There the authority offers for the end-users the information and prices about all the generally available electricity contracts and the statistics of both energy and distribution prices.

The customer can have a fixed-price contract that is either valid indefinitely or for a fixed term. Other possible alternatives are a contract with dynamic price and a two-time-price contract that has e.g. different price for night and daytime energy, or for the winter and summertime. A customer specific contract is also an option but it is used especially with bigger industrial customers. The type of the electricity contract is marked in the supplier's customer information system and in the framework of DR the spot price based contract is the basis. The essential contract types are discussed in the sub-sections.

In the near future, there will become an option to make an electricity agreement also with a supplier outside of Finland. In principle, a supplier in one country could offer contracts to households in another Nordic countries and later even a Europe-wide electricity retail market is possible. The well-functioning Nordic wholesale market shows that international retail market could work for small business and households too. The previously presented datahub and NBS projects are building the basis for the common Nordic end-user market. (NordREG 2014)

### 3.2.1 A fixed-term electricity contract

A fixed-price contract concluded by the supplier and the end-user is either valid indefinitely or for a fixed term. Typically fixed-term contracts are made for one or two years and the customer pays a fixed price for his electricity during that contract period. In this kind of agreement the positive or negative price risk is directed only to the supplier. (Finnish Energy Industries 2014a)

According to *Electricity market procedural instructions,* a fixed-term sale contract continues as an indefinite period after the end of the term, if no new sale contract has been made between the supplier and the customer or if neither party has terminated the contract at two weeks' notice. If a fixed-term sale contract expires before the due date, the supplier is entitled to collect a reasonable contractual penalty from the customer, if the penalty and its amount have separately been agreed upon in an individual sale contract.

A fixed-price contract consists of the monthly basic fee and a consumption based energy fee, c/kWh. For example, Lahti Energia Oy offers a fixed-term one year contract, Etupesä Yleissähkö 12kk, where the basic fee is 1,00 €/month and the energy fee is 5,18 c/kWh. Therefore, the electricity for a customer living in a typical apartment house with an annual consumption of 2 MWh would cost 115,60 € per year. The price includes VAT for the energy. Adding the distribution and electricity tax roughly doubles the electricity bill. (Energy Authority 2014c)

So far, the customers have widely appreciated a fixed price for the electricity because they are used to consume energy whenever they want. With this kind of contracts the consumer does not have any price risk. This contract reminds the futures and forwards which industrial customers buy on finance markets. They use the financial contracts for price hedging and risk management, as the households like to do as well.

### 3.2.2 An hourly priced electricity contract

Dynamically priced electricity sale contracts begin to get more common now that new AMR meters enable to measure electricity consumption by hour in the households. In these contracts the electricity price is different for every hour and the price adapts to the spot price. They motivate the customers to use energy on the cheaper hours creating price based DR. These contracts are typically valid indefinitely.

The contract based on the electricity price in the exchange has typically a monthly basic fee and a marginal added to the spot price. For example, Oulun Sähkönmyynti Oy offers a spot price contract, Varmavirta Spot Yleissähkö, which consists of the basic fee of 5,00 €/month and a marginal of 0,25 c/kWh added to the spot price in the Finnish price area (Elspot FIN). The company offers also an extra option to cover the electricity usage with a price roof. This voluntary price roof protects the customer from the price peaks in the Nord Pool exchange keeping the maximum price per hour for the customer at 8,60 c/kWh. However, the price roof service costs 5,00 € extra per month as the supplier takes the peak price risk. With the price insurance it is hard for a general customer to make this kind of contract a profitable choice. (Energy Authority 2014c)

Among Nord Pool the average spot price in year 2013 was 4,12 €/kWh in Finland. Referring to the example in previous sub-chapter, if the same household with the annual consumption of 2 MWh has this kind of contract, it would generate an electricity bill of 142,2 € per year with the average spot price. Already without the price insurance that is much more than a general fixed-price contract. In practice, this kind of dynamic contract is profitable only if the customer uses load control.

### 3.2.3 Selling own production

More and more end-users are interested in having own energy production, e.g. a wind turbine or solar panels. Distributed energy production is trendy and most end-users prefer the green values to saving money. The most economic situation for the end-user is to consume all the produced energy directly or use it for storage heating. If the production goes over the consumption temporary in the household the over-production could also be loaded in a battery. However, the battery system is usually too expensive choice so it is better option to feed the rare overproduction to the grid, with compensation or not.

According to the *Guideline for AMR metering* the local grid company is obliged to connect households' energy production to the grid if the production equipment fulfills set conditions. The production and consumption behind a connection has to be metered separately by hour, i.e. the electricity taken and fed to the grid shall not be netted. If the usage place has the maximum of 3x63 A main fuses the same AMR meter can measure both the taken and fed electricity to the grid.

To connect the production to the grid the customer just needs to have a valid network service agreement that will be expanded with *Appendix to the Terms and Conditions Concerning Network Services for Electricity Generation*. There has to be a buyer for all the electricity fed to the grid. Therefore, the customer's energy supplier (open supplier) has to receive all the overproduction according to the Government decree (2009). The customer can also have separate contracts with separate energy companies for electricity sale and purchase. However, there are already several suppliers who offer an electricity contract that includes both the purchase and sale of energy. (Finnish Energy Industries 2013c)

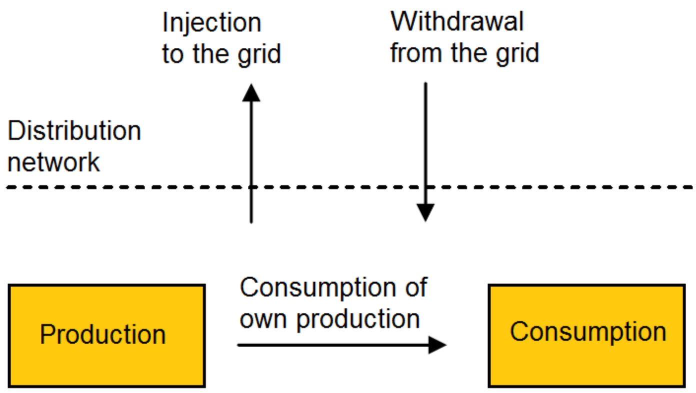


***Figure 3.1***: *Electricity connection with both consumption and production. The connection is under the dotted line and the arrows describe the energy flow. (Finnish Energy Industries 2010)*

Energy company Oulun Sähkönmyynti is taking advance in implementation of buying and selling electricity produced in households. Its product Farmivirta pays the producer for the energy fed to the grid and also makes it even possible to other customers to buy that home-produced electricity. Additionally, in this arrangement the producer also ensures that the produced electricity comes from renewable energy sources. This electricity contract was nominated as Vuoden Ilmastoteko 2014 (the climate act of the year). (Oulun Sähkönmyynti Oy 2014)

### 3.2.4 Distribution tariffs

Both energy and power have an impact on the overall energy efficiency of the electric power system so therefore a pricing system that only encourages to minimize the energy use does not necessarily produce the best result. Incentives are required to reduce the peak power and optimize the temporal variation of power. Among the Government Decree (2009) the DSO shall offer metering services based on hourly metering, for a flat rate tariff, for a two-rate tariff (day/night) and for a seasonal tariff (winter weekday and other energy).

In the present tariffs, the flat rate tariff consists of a basic charge (€/month) and an energy rate (cent/kWh), which is constant regardless of the time of use. The fixed monthly charge is based on the size of the main fuse, which in itself promotes the optimal dimensioning of the connection point. In practice, the power is limited only by the size of the main fuse, which is typically 3x25 A in households. However, the energy component encourages reduction of the total consumption of energy. (Partanen & al. 2012)

For example, DSO Elenia offers general electricity tariff which is the most common choice for households. The monthly basic fee according to the main fuse size is 13,61 € with fuses of 3x25 A. The distribution costs 3,61 cents per kWh excluding the electricity tax. The prices include VAT. The yearly network service costs for a customer with annual consumption of 2 MWh will be 235,52 € in the network area of Elenia. As the electricity tax (2,36 c/kWh in class 1) is invoiced on the same bill, the total sum will become 282,71 €. (Elenia Oyj 2014)

The two-rate tariff consists of a basic charge which depends, again, on the size of the main fuse and an energy rate which is lower in the night-time. The night-time is usually between 22-07. This tariff includes an incentive to schedule the electricity use to the night-time whenever possible. In practice, this tariff type is used in households with accumulating electric heating. The target of the tariff is to balance loads by shifting the electricity use to the night-time when electricity is typically used least and its spot price is therefore lower. This tariff arrangement has been popular in Finland and it is one kind of DR as well. (Partanen & al. 2012)

## 3.3 Processes related to electricity contract

Basic electricity business consists of different processes, e.g. electricity connection process and making a new sale contract. This paragraph introduces the processes that are important to understand for the basis for demand response contracts. The following processes are closely related to customer interface and these usually rise from customer's actions. Even though the processes handle the issues concerning the end-user the processes are not visible for the customer itself but are dealt between the electricity market parties.

A well-functioning and actual information exchange as introduced in chapter *2.3 Information exchange* enhances and supports the process flow. The sub-sections describe the processes as they appear now, and later in chapter 6 will come suggestions for additions to these processes that would make the DR contracts possible to apply.

### 3.3.1 New Customer

This process starts when a supplier gets a new customer. The customer makes a new electricity supply contract orally, in the internet or written. The electricity supply starts within time announced and the customer does not have to contact the DSO to start the delivery.

The start and end of sale must be based on the procedure defined in the *Message exchange procedural instructions*. After concluding a new sale contract with a customer, the new supplier shall report this without delay to the DSO with a Z03[1] message. The new supplier may also be the current supplier of the metering point if the customer changes his contract type or makes a new contract. The new contract number must be transmitted to the DSO with the Z03[1] message. If the user's site requires metering changes, the notice from the supplier to the DSO must be received at least 21 days before the start of the contract.

The process chart of making a new sale contract is found in appendix B. There the communication and message exchange is described on a timeline between the customer, the new supplier, the DSO and the possible old supplier.

### 3.3.2 Switching the supplier

The products the supplier can offer and the duration of contracts are important drivers for a customer to change his supplier. Supplier switching has increased in Nordic countries in the previous years. According to a survey of NordREG 10% of customers switched their supplier in year 2013 in Finland. (NordREG 2014)

*Electricity market procedural instructions* tells what has to be done in this process. Firstly, when the customer concludes a new sale contract, the old contract for electricity sale must be terminated. If the old contract is valid until further notice, it is normally terminated after a two-week period of notice. The contract will usually be terminated by the new supplier on the customer’s behalf. The new supplier notifies the DSO of the contract immediately after the contract has been concluded. The DSO further notifies the current supplier of the new contract.

The new supplier has to inform customer’s DSO about the new contract at the earliest three months, and at the latest 14 days before the start of supply. The message must include customer’s metering point ID and proposed begin of supply date. The DSO informs the customer’s current supplier with message Z05[1]. The current supplier sends the DSO a message about whether the new supply can be started, Z08[1], or sends a negative message Z08[N] in the case if the customer has a valid fixed-term contract. The DSO informs the new supplier about starting the supply or not within five workdays of the new supplier’s first message. At the same time the DSO also sends estimation on customer’s annual electricity consumption. (Finnish Energy Industries 2014a)

On the message exchange level the supplier switching procedure starts from new supplier's Z03[1] message to the DSO. With that message the new supplier notifies the DSO of the new sale contract to the metering point located within the network area of the DSO. As defined in Message exchange procedural instructions, the message exchange chain consist of Prodat messages Z03[1], Z05[1], Z08[1] or Z08[N] and Z04[1] or Z04[N] sent within the new supplier, DSO and the current supplier. The last message Z04 confirms the start of the sale with reason code 1.

Switching the supplier is easy for the customer since it requires only one contact. Behind that, the process and the message exchange follows also mainly the process of appendix B. Another simpler chart is shown in figure 3.2. Developing the centralized datahub makes the information exchange possible also in the future when switching to a supplier in another Nordic country.

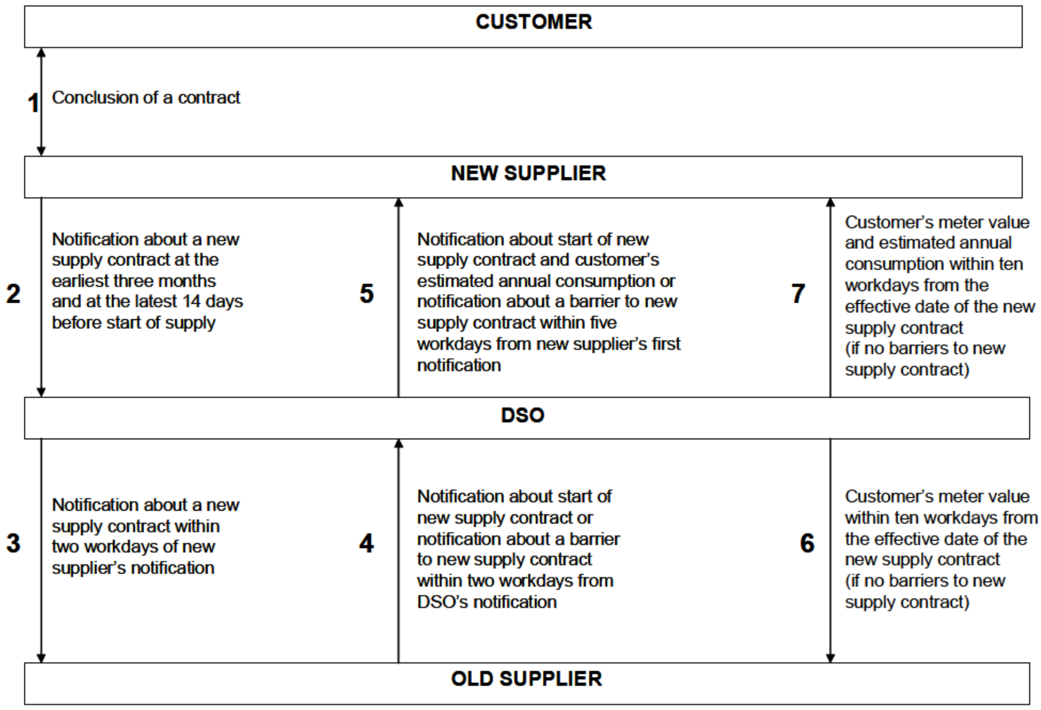


***Figure 3.2**. Supplier switching process. In phases 6 and 7 the DSO informs the suppliers within five work days. (Annala & al. 2009)*

### 3.3.3 Moving

The customer needs to manage the contractual actions related to his move only with the supplier for the place he is moving into. A move is strongly based on the processes described above, but the situation entails some special features. For the customer, the hardest thing is to remember to conclude the new contract early enough. The moving process can take several days even though the move situation is dealt with as quickly as possible by all parties. Anyway, if the electricity contract for the new usage place have not been concluded early enough the local supplier secures with delivering the electricity.

The greatest difference in moving compared to previous processes is the termination of supply to the metering point where the customer is moving out of, carried out by the supplier of the metering point where the customer is moving into. When a customer moves out, the electricity sale contract may be terminated even if it is made for a fixed term. Among *Message exchange procedural instructions*, in the move situation the messages are identified with the reason code 14, so there is no need to inspect notices of termination carried out in normal situations.

*Electricity market procedural instructions* give further instructions in the moving process. The new supplier notifies the DSO of the metering point from where the customer is moving out of the termination of the contract in accordance with the Message exchange procedural instructions. The DSO passes on the information about the termination to the supplier of the metering point from where the customer is moving out. With this information, the DSO and the previous supplier may terminate their contracts and send their final invoices to the customer.

The step-by-step message exchange in case the customer reports the move to the desired supplier at the new metering point is found in appendix C. The process is simpler if the customer only reports of the move out or in or if the supplier is the same in both the old and new metering points.

### 3.3.4 Invoicing

The customers who do not buy electricity from the local supplier receive separate electricity supply bill from their supplier and network service bill from their DSO. The DSO delivers the metering data for the supplier to generate the electricity bill. The reading of hourly metered sites is carried out once a day.

Sometimes the exact consumption per hour cannot be accessed and the DSO has to send the supplier estimated values for a metering point instead of the actual time series. Therefore, the status of hourly data always tells the reliability of the data. If the customer will be invoiced based on some estimated or missing values there has to be a notation of this on the bill. The difference will be corrected on the next bill when the DSO has delivered the corrected time series for the supplier. (Finnish Energy Industries 2013d)

The supplier informs the DSO with the reason for billing field if it has concluded with the customer about billing based on actual or estimated time series. As the AMR metering is nowadays the default with household customers, the actual time series will be used. On behalf, the DSO confirms for the supplier the real reason for billing with the same field. There rose a need for this kind of field in the messages and first it was voluntary to use, but from the beginning of 2012 it has been compulsory. Like in this case, there will rise further need for new message fields when applying DR products. (Finnish Energy Industries 2013e)

The DSO sends the information for billing with Z11-messages. The supplier gets all the meter readings and possible changes in annual consumption estimates based on the reading. Z11[5] informs the actual metering data for consumption-based invoicing during supply. The DSO also uses the same information for the basis of its customer balancing. (Finnish Energy Industries 2014a)

# 4. SMART GRID AND DEMAND RESPONSE

The electricity market has been developing rapidly and will continue to develop in the near future. The electricity production and consumption structure has changed because of the growing amount of renewable energy. Consequently, EU has set a series of ambitious climate and energy targets to be met by 2020, known as the "20-20-20" targets. When the intermittent energy production increases enough the old functionalities of the grid becomes insufficient. Therefore, an intelligent and flexible smart grid is needed to enable all the communication that efficient electricity transmission requires in the future.

Demand response is needed to handle the changing energy production structure and it is not possible without smart grid that enables the two-way electricity flow. When the economic situation improves, electric cars will generalise and the use of heat pumps grows the electricity consumption, which leads to increased peak load on the system. With DR and load control, the peak load on the grid can be reduced and, furthermore, grid reinforcements can be delayed or possibly even prevented. Additional value can be created by reduction of grid losses by establishing a better local balance between supply and demand. The achieved benefits depend on by which party's preferences the load control is made. (Smart Energy Collective 2013)

This chapter discusses the trends and terms that are researched widely within the past few years in the energy industry. The sub-sections introduce the basics of important factors in the framework enabling D. Smart grid and DR have been widely researched and in this study they will be discussed from the view of their market potential.

## 4.1 Smart Grid

Two-way electricity transmission will increase, meaning that original consumption places can sometimes show up in the network as a production plant feeding electricity to the grid. Furthermore, increasing wind and solar power capacity also means an increase in unpredicted electricity generation in the network. The change in the use of the network requires smart grid. The AMR metering and two-way data transfer between the grid and the usage place play a significant role in smart grid. (Finnish Energy Industries 2010)

The figure 4.1 illustrates the electricity flow in the smart grid and the structure of tomorrow's electricity network. The traditional grid is planned top-down, from the power plant to an electricity usage place, where the energy runs always in the same direction. In the smart grid the energy can flow from one usage place to any other party.

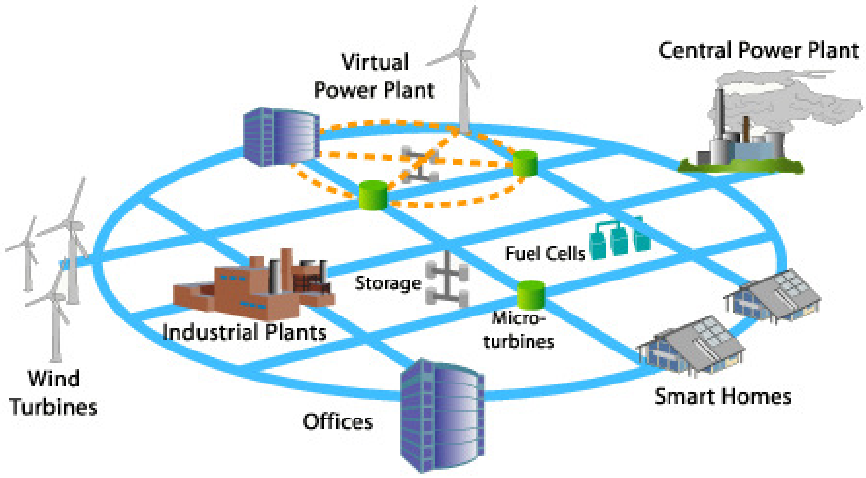


***Figure 4.1***. *The structure of smart grid society. (Osi 2014)*

Before the electricity production has been controlled among its temporal consumption. Now that the capacity of controllable production decreases either the consumption has to bend or the produced energy has to be stored for further use. Besides batteries electricity can be stored for example in a heat storage, flywheel, supercapasitor or superconducting magnetic energy storage (SMES). However, the technologies are still expensive and energy transformation always creates losses. Batteries are still waiting for their days of glory in their storage capacity in both kWh/kg and €/kWh. Energy storage has been widely explored within smart grid and further discuss about the technology is not in the main scope of this study. (Roberts & Sandberg 2011)

Using the batteries as one element in the smart grid creates flexibility, which can be seen both positive or negative depending on if their injection to the grid can be predicted and controlled or not. Later, the customers can use their batteries freely and sometimes even feed the electricity to the grid during an expensive spot hour if it can bring financial benefit for them through a contractual arrangement. In this case the supplier ends up in a difficult situation because it becomes hard to plan the electricity purchase for each hour. Therefore the usage of private batteries is challenging in the smart grid because their feed in and from the grid is even harder to predict than it is for renewable energy. At least with intermittent production the supplier can plan his electricity purchase based on weather forecasts. However, dynamic electricity contracts that base on the spot price already cause same challenges to the supplier to predict the consumption.

In business as usual scenario the battery capacity in the grid will increase among the electric vehicles. If the suppliers can access the batteries and use them to balance their balance sum the batteries can be seen as a huge opportunity in the smart grid. Chapter *6.4.1 Additional value and following the consumption* will touch on the business potential that customers' batteries can offer to the supplier.

Distributed electricity production and households' own electricity generation is a significant feature in future's smart grid. The Ministry of Employment and the Economy discusses net billing in its report *National Energy and Climate Strategy* from year 2013. In net billing the electricity consumer would sell his excess electricity production to the grid and use a corresponding amount of electricity at some other time when electricity is probably more expensive. In the present situation the electricity fed in and from the grid is not allowed to be netted. From the perspective of load control, the weakness of statutory net billing is that it does not encourage small-scale producers to optimize their production and consumption according to when there is a shortage of electricity on the market.

## 4.2 Demand response

Energy price based demand response means the situation where the electricity consumption is shifted from the more expensive spot hours to the cheaper hours. The basic idea of DR can be carried out with both direct and indirect control of the loads. If customers have a spot priced electricity contract they will prefer to use electricity on the cheaper hours, which leads to price-based DR. They can switch the loads on and off themselves or loads can be connected to a HEMS that is controlled by market-price-based signals. Another option is to let the supplier to control customer's loads through a HEMS or AMR meter. (Valtonen & al. 2012)

The figure 4.2 illustrates the variation of the spot price on three different days in May 2014 in Finnish price area. The highest price peak was on Tuesday 6$^{th}$ May on the hour starting at 8 am when the price for electricity was 8,0 c/kWh. On the same day the lowest price for electricity was 2,9 c/kWh on the hour starting at 3 am. On Saturday 10$^{th}$ of May the electricity price stayed exceptionally low and stable, the highest spot price rose to only 3,4 c/kWh.

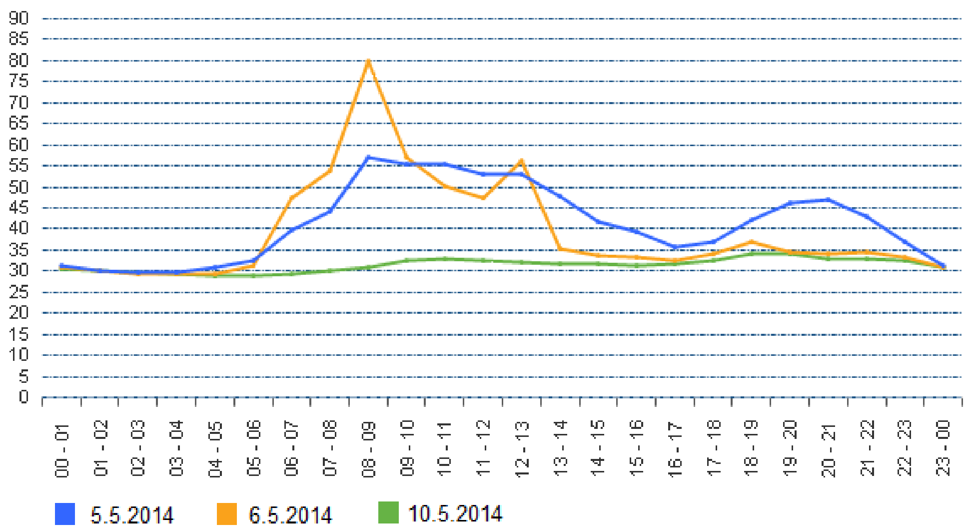


***Figure 4.2**. Hourly price in EUR/MWh. (Nord Pool 2014)*

Typically the electricity is cheap during the night and there are price peaks in the morning between 07-10 and another, probably lower, price peak on the afternoon between 17-20. The figure 4.3 demonstrates the electricity price within a normal Tuesday in Finland. DR can smoothen especially the demand volatility during one day.

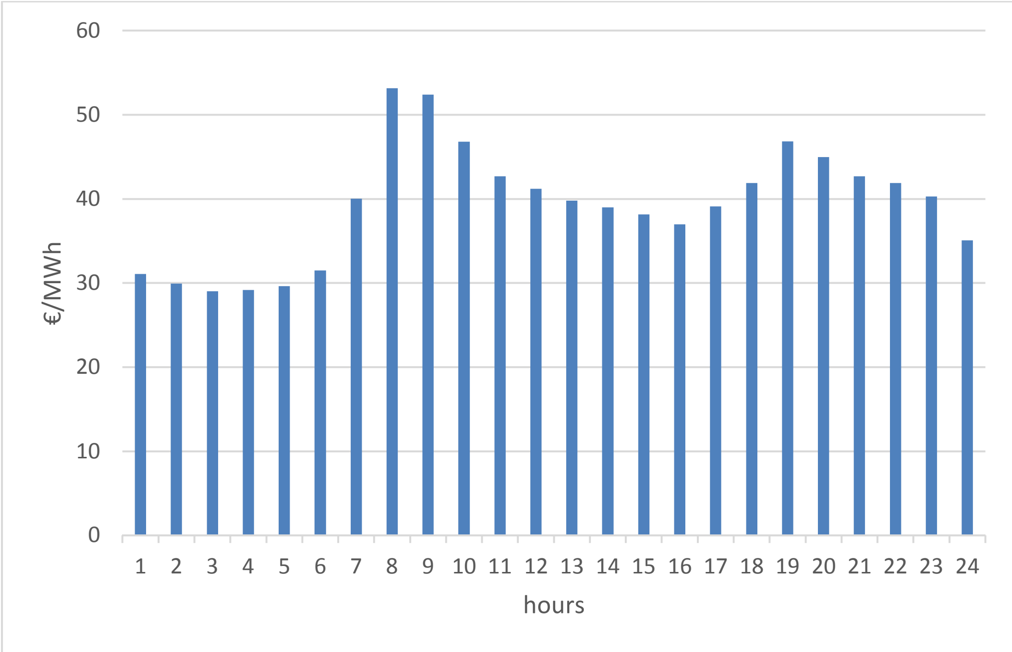


***Figure 4.3****. Elspot FIN prices on 20.5.2014. (Nord Pool 2014)*

Besides price-based flexibility, DR can be carried out also with direct load control by the supplier. The supplier can offer its customers electricity contracts that include incentives to allow the supplier to steer customers' loads. That way both the customer and the supplier can save money when avoiding significant electricity usage during expensive spot hours. The AMR meter could automatically decrease the consumption level of the customer if consumption goes over a set price limit, for example by turning the heating off. This kind of steering is already used by some bigger industrial actors who can adjust their production processes easily. This study will examine how the same functionality could be implemented in the customer interface by combining household loads into bigger groups.

Demand of electricity has high impact on electricity price. Even a rather small increase of DR can decrease electricity price significantly, especially during the peak load hours. The impact on the price depends on the structure of production capacity and characteristics of the power system. Naturally, customers operation and willingness to promote DR in different situations can vary. (Valtonen & al. 2012)

When using load control widely there exists a risk of an expensive after-peak after a high spot hour price. This occurs when all the loads turned off will be switched on again at the same time. Besides the financial after-peaks there becomes also challenges with the power peaks from the network point of view when a great amount of loads are switched on at the same time. For example, to avoid that problem TSO Fingrid has advised the DSOs to turn its customers' night-loads graduated on to soften the power peak of 22:00. (Finnish Energy Industries 2010)

DR involves the distribution network, suppliers, producers, the end-user and the energy market on many levels. In the following sub-sections the DR will be presented in two different points of view declaring the possibilities it has to offer for the society and the supplier. The benefits for an end-user are discussed in chapter *4.3 Active customer*.

### 4.2.1 Demand response for the system and society

Demand response enables optimized use of grid capacity so it is an alternative for large-scale network investments for the TSO and DSOs. It also lowers the need for generation and reserve power capacity because the consumption can be shifted till later if there is a shortage of electricity on a particular hour in the Finnish price area. Great socio-ecomonic saving can be achieved also when offering the supplier's DR potential to TSO's reserve market.

Utilizing DR would increase the self-sufficiency level in Finnish energy production because in the present situation imported electricity is always needed on the peak hours. The net electricity import in year 2013 was 15,7 TWh which is nearly one fifth of total acquisition of electricity in Finland. The amount is relatively high and the dependence of imported energy reminds that Finland needs new investments to electricity production. If the increasing capacity will be covered with renewable energy production, DR is again needed to help in handling the growing part of intermittent production. The year 2013 was one of the years with highest percent of imported electricity and it is mainly explained by the good water level of that year in Nordic electricity market. The greatest part of imported electricity was purchased from Sweden. (Finnish Energy Industries 2014b)

DR is needed to utilize all the distributed energy production so, therefore, it has environment-friendly impacts. The local energy production and consumption balance also increases which leads to decreased transmission losses because the electricity does not have to be transmitted considerable long distances. All this also lowers the costs of supply. (Smart Energy Collective 2013)

DSO can benefit from DR through suitable control of the loads by cutting the peak power. In this case the expensive grid investments can be postponed or maybe even left out. However, the Finnish regulation model incites the DSOs to invest on their grids. It makes it profitable to invest on infrastructure for DR but, first of all, to invest on traditional solutions like strengthening the grid to remove bottlenecks. (Energy Authority 2011) On the other hand, the achieved benefits of DR depend on whose preferences DR is carried out. If a wide customer mass has dynamic electricity contracts and they all want to utilize the extra cheap spot hours, it can even increase local peak power and, therefore, rise the grid investments.

The BRPs DR will help in balance management. The maintenance and operational costs for reserve power are high and in the best scenario a BRP can avoid building a new and expensive reserve power plant. This far a typical option for a BRP to accomplish balance management during high demand hours has been to dispatch power plants with which it has a contractual agreement. DR provides another alternative by activating the flexibility in supply and demand that its customers offer. Trading on the imbalance market and supporting the TSO in maintaining the system balance can create additional value for a BRP. (Smart Energy Collective 2013)

### 4.2.2 Demand response for the supplier

Demand response offers a tool for the suppliers to both plan and hedge their long-term electricity procurements and to optimize the short-term physical electricity procurement as well. For example, the level of long-term hedging can be lowered and the trading in Elbas market can be reduced if the supplier has enough controllable resources for DR. Using load control instead of expensive market electricity during peak hours or instead of regulating power, at least partly, brings economic advance for the supplier, because especially the level and volatility of imbalance power prices can be rather high compared to average spot prices. (Smart Energy Collective 2013)

The greatest risks faced by the supplier in the electricity markets cover the price risk and volume risk. A supplier’s short-term profit optimization includes trades in the day-ahead, intra-day and real time (balancing power) markets, and possible utilization of controllable distributed energy resources. Usually the supplier hedges its electricity by using financial products (like futures and forwards), but it still has to procure the actual energy from the physical power markets. The supplier aims to manage its open position close to zero level when the delivery hour approaches, meaning to get the electricity procurement (production) and consumption (sale) in balance. Unfortunately, there is almost always difference between forecasted and actual electricity consumption and the electricity procurements and hedging made in advance do not match precisely to actual consumption. (Valtonen & al. 2012)

As noticed, it is impossible, or at least unprofitable, to try to get the open position to zero. Therefore, in traditional market environment, at the times of high market prices the supplier should rather have a bit positive open position (surplus electricity procurements), which provides a profitable sell-back opportunity. When the market prices are low, the open position is better to keep negative. The figure 4.3 shows the consistence of supplier’s (retailer’s) electricity procurement costs. The blue boxes show the traditional factors affecting the costs and it also visualizes where the DR takes up a position. (Valtonen & al. 2012)

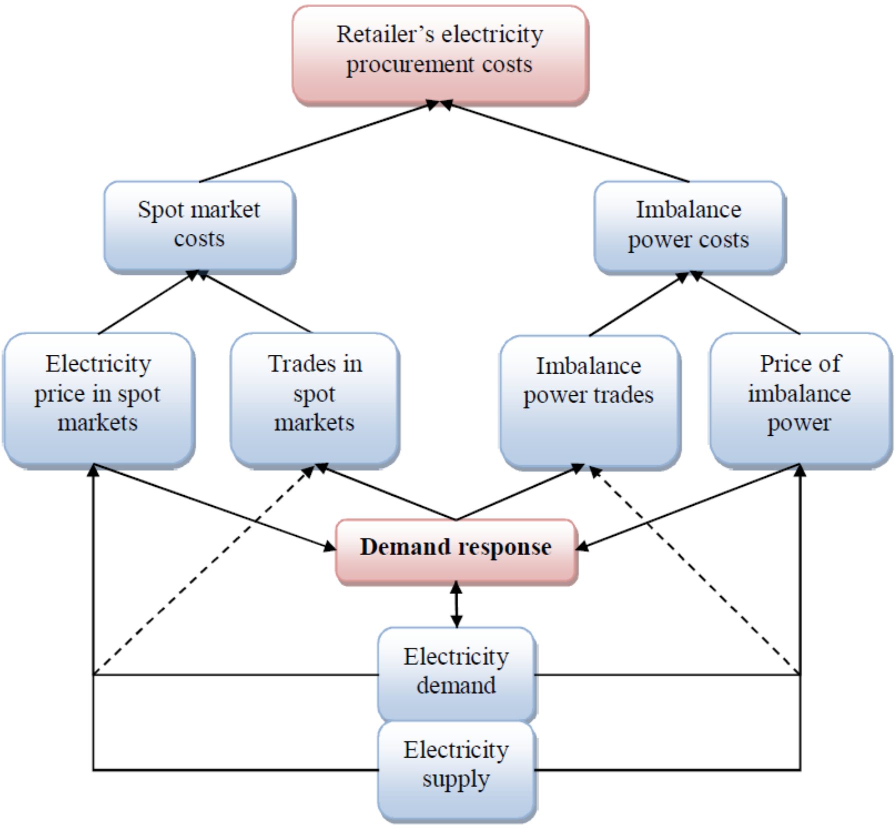


***Figure 4.4.*** *Impact of DR on a supplier's electricity procurement costs in short-term markets. (Valtonen & al. 2012)*

As further pointed out in Valtonen & al. (2012), the uncertainties related to electricity price and consumption depend highly on the existing operational and market environment. DR may provide hedge against wholesale price risk, increased total margin and even increase of overall sales. In near future, DR will relieve the short-term planning in the management of open position that the supplier has after long-term hedging. This is an important factor because the possibilities to hedge against price variation weakens when the delivery hour approaches.

DR brings also further value for the supplier if it chooses to use DR resources to make bids in Elbas market or in the regulating and reserve power market. In best scenario this brings new revenue streams and competitive advantage for the supplier. DR is also a worthwhile alternative to handle the supplier's own balance management. (Smart Energy Collective 2013)

## 4.3 Active customer

Smart Energy Collective (2013) differs an active customer from traditional passive customer according to its ability to change its consumption based on the electricity spot price. In smart grid environment household level low-volume end-users will become so-called prosumers who actively participate in the future energy system. The trendy term prosumer is combined from producer and consumer, but the customer does not need to have own production in order to become active customer. The behavior of active customers will have a major impact on the entire energy system as the smart energy framework will enable consumers to transform into modern individuals feeding energy to and from the grid, creating affordable and sustainable energy system.

This far the supplier has bought electricity for each hour based on customers' predicted load curves. Therefore, an active customer causes a risk for the supplier. Behavior of the active customers leads to situation where the supplier cannot predict its customers consumption profile for sure, which often causes increased purchasing costs of electricity.

Therefore, DR will change the relationship between a supplier and a customer when the customer becomes a resource or a cooperation partner. DR is based on the idea that customers' electricity use changes from their normal consumption patterns according to the price of electricity over time, which brings benefits for both the supplier and the customer. For example, besides drifting the customer's consumption, DR can be achieved also as a result of the use of customer owned distributed generation or energy storages. (Valtonen & al. 2012)

As the supplier benefits the DR by directing its customers' loads into desired direction, the customers benefit this by achieving savings in their electricity costs. DR may lower both the energy and transmission costs for the end-user. The lower transmission fees are a result from more efficient use of the present transmission and distribution grid. Lower energy costs derivate from optimization of energy consumption because of the dynamic tariffs.

Customer enabled energy efficiency brings savings for the customer itself, but for the other market parties and the society as well. This requires sufficient incentives from the electricity contract, appliances and automation planned for DR. A well planned and executed DR interface between the supplier and the customer provides an opportunity to commit the customer. A satisfied customer is not eager to change his electricity supplier and, for example, a longer customer-supplier relationship offers a better framework to develop more advanced HEMS applications for intelligent load control. (Heiskanen & al. 2012)

The only direct benefit DR has to offer for a customer is the saving in electricity bill. If customer appreciates the possibility to control its loads remotely or automated the possible HEMS application connected to AMR meter brings also extra value for him. The opportunities offered by load control are presented later in this chapter and other possible extra values later in this study. When choosing a spot price based electricity contract and the supporting appliances and software to get the most out of the contract the customer's awareness about electricity usage improves too.

## 4.4 Load control

DR can be carried out in the spot market and balancing power market through automated customer load control. Steering the loads in a general household is one central feature of future smart grid environment. Direct steering can be used when connecting specific loads behind a relay in a modern AMR electricity meter or a home automation system, HEMS. Load control can be achieved with newly installed AMR systems alone, but using also HEMS enables more complicated ways to steer the loads.

AMR meters that are newly installed in Finland have to be able to send and receive external control signals, and execute on/off-type load controls. This kind of functionalities offer new opportunities to improve profitability of the retail business and the promotion of DR. Based on the control signals, such as electricity price, customers' electricity consumption can be controlled in certain limits in a way that provides the optimal results. (Valtonen & al. 2012)

According to Valtonen & al. (2012), the real-time pricing is seen as potential alternative to improve the DR. Electricity price signals can be transferred to customers with minor delays through AMR systems, which makes simple and cost-efficient implementation of time differentiated pricing models possible in practice. Customers response can be achieved by customers own actions or using HEMS. Automated control provides typically the best results.

The Government decree about electricity metering recommends to equip the AMR meters with at least one relay for load control. Another technical solution for this kind of load control possibility is also acceptable. In usage places with reserving electric heating the first relay is usually used to heat the apartment up during night-time, and an additional relay would be needed for another DR control.

*Terms of electricity sales* sets a following restriction for the load control executed by the supplier and the DSO:

*2.9.4. As regards direct electric heating mainly by means of direct electric heaters, the number of de-energised hours of the heating elements may not exceed 1.5 hours at a time and 5 hours a day. Each separate de-energised period shall be followed by an energised period of at least the same duration as the de-energised period. (Finnish Energy Industries 2014c)*

If the supplier wants to steer its customers' loads they need to have a written contract that clearly specifies the rights and restrictions for both contract parties. Then the supplier can restrict the availability of a customer's electricity or steer the use of electricity in some other way. If load control is utilized by AMR meters, the actual steering involves the DSO who owns the AMR equipment and transacts the actual control signals. If the usage place is equipped with external HEMS appliance, owned by either the customer or supplier, DSO is not involved in the steering process. (Energy Authority 2014a)

As discussed this far, load control offers a tool to smoothen the electricity consumption peaks. One kind of load control is already the use of night-time and daytime tariffs which were presented in chapter *3.2 Present electricity contract*. The usage places with reserving electric heating benefit from cheaper electricity during nights when their loads are switched on after 22:00. However, the control does not monitor the state and needs of the electric power system when numerous boilers are simultaneously switched on. They may cause problems both in the distribution system and in the national power balance and if the amount of steering increases, its challenges need to be researched carefully. (Partanen & al. 2012)

Nowadays, the electric heating is the easiest load to steer. In the future, the electric cars and heat pumps in combination with heat storages are a good addition. They have a much higher demand flexibility potential than for example washing machines, tumble dryers, dish washers or car heaters. Using refrigerators and freezers as DR loads divides opinions. The control potential of households' electric appliances and controllable device groups will be discussed more in chapter *6.3.3 Control groups.*

Basic level of steering is possible to carry out with only the AMR meters. If more specified load control possibilities is needed, some kind of HEMS devices are necessary. There are several HEMS devices on the market with different user interfaces. For example, Vattenfall offers SmartPlug as its solution to control customers' own electricity consumption. It is a simple device connected to a socket and that way the customer can steer freely the load behind that plug through a mobile application. (Vattenfall 2014b)

Besides the SmartPlugs a customer can expand the control possibilities to energy monitoring service. The recording unit of EnergyWatch will be connected to customer's AMR meter and then the software shows in real-time (by minute) the changes in electricity consumption, and how much different loads use electricity. The program requires a WLAN for the recording unit to transmit the measured data. Customer's account can be surveyed with a software in both web and mobile application. If the account can access the electricity price the customer is able to make cost analyses based on his consumption. (Vattenfall 2014b)

# 5. METHODS AND MATERIALS

The empirical material for this study was collected in interviews with representatives from electricity supply companies. Interviews were recorded and answers were later written down. A thematic analysis was then conducted in order to find out what kind of issues the chosen experts emphasize. The empirical material provides an overview of issues impacting on demand response product implementation in the interface of the supplier and the customer. The answers offer information what the experts wish from the electricity contracts, how they see the business field to change within this framework and in which role they see DR in the future.

The first sub-chapter reports about conducting the interviews. The second sub-chapter collects the answers and presents the overview gained in the interviews. Finally, the main issues of the thematic analysis are opened in the last sub-chapter and reflected with the theory background.

## 5.1 Progression of the interviews

Interviews are divided into structured, semi-structured and unstructured interviews depending on how tightly the questions and the interview situation are planned. Interviews in this study were made in a semi-structured manner. The structure is looser than in a structured interview, but usually some prepared questions exist to lead the interview and to help the researcher to get some answers to the research questions. (Ruusuvuori & Tiittula 2005)

Interviews in this study were based on a list of questions. However, the interviewees could quite freely emphasize some questions based on their knowledge and interest. Semi-structured interviews allow the interviewer to improvise, which means that in order to gain extra information, complementary questions can be made during the interview. Some questions were also left unasked.

Since demand response has been researched widely, there was already material for the basis for new interview questions. The inquiry for the suppliers created by “DR-pooli” was a great inspiration for the questions asked in the interviews for this study. DR-pooli is a two-year research project about DR and its practical solutions suitable in Finland and its impacts for DSOs (Finnish Energy Industries 2014d). The answers for the inquiry was not received when the interviews were made. The interview questions asked in the interviews for this study can be found in appendices D and E (in Finnish and English). Interviews were made in Finnish because all the respondents were Finnish.

The interview questions were divided firstly in questions concerning the present situation of the supplier company and its contract products, secondly their future visions about the electricity supply business concerning DR and, thirdly, about their expectations for load control. Central questions was related to dynamic pricing and incentives for contracts allowing load control. The aim was to find out how they see the customer interface to change in the future. Because the question list for the interviews was rather broad, it was sent to the respondents in advance so they could become familiar with the themes and questions. Interviewees were told that if necessary, they could skip difficult questions and concentrate more on the themes that they have more to say.

Interviewees were found from energy supply companies participating the development of Empower IM's new customer information system *EnerimCIS*. Five customer companies of Empower IM were asked for an interview and interviews managed to be concluded with three of them. The interviews were made as phone meetings in September 2014. The interviewees can be found in table 5.1.

***Table 5.1***. *The Interviewees and the companies they were representing.*

| | |
|---|---|
| Olli Arola, department manager for electricity trading<br>Jyrki Rajala, project manager | Vaasan Sähkö |
| Petri Rantakokko, energy manager | Jyväskylän Energia |
| Antti Rytioja, sales manager | Kokkolan Energia |

Regardless of the limited amount of interviews, it can be concluded that the group of interviewees and their expertise cover the aspects of this study quite well. For the most part, the interviewees in this research emphasized similar issues. The three small- and midsized companies represented well Finnish electricity suppliers. There are nearly hundred electricity supply companies in Finland and most of them are relatively small. Collecting opinions from smaller companies was useful considering the customer set of Empower IM.

An extra interview was made with a smart housing developer to discuss the situation of present home automation systems. As interviewee was Eetu Prehti from Spartacus Technologies which is a start-up company from Tampere University of Technology. The company has developed an open-source smart home solution, with which the user can control devices and monitor his home. Their project *Auxilo* show that controlling your home does not need an expensive turnkey solution. However, at this point their project did not have connection to electricity price.

## 5.2 Analysis for the answers

Thematic analysis was used as a method for the analysis of the interview answers. In thematic analysis the interview material is organized into themed categories. Themes refer to specific patterns which can be found in the collected data. Alternatively, themes can be formed on the basis of the theory and the framework of the research. In this study the themes are formed based on both the interview data and the theory in the beginning of this study. (Yardley & Marks 2003)

The answers were themed based on the issues that evoked the most discussion in the interviews. In the left column of the table 5.2 the topics are firstly divided into five main themes. In the right column there are complementary subthemes that are specified from the main topic. The subthemes are partly overlapping, so one subtheme could have been connected to more than one topic.

***Table 5.2**. Themes and subthemes used in the analysis.*

| | |
|---|---|
| **Standardization** | - several suppliers operating in the network of a DSO<br>- policies to handle payment and on-off-switching disruptions |
| **Dynamic electricity price** | - customer's own HEMS is necessary<br>- active customer forms a risk for the supplier<br>- easy to implement from the technical point of view |
| **Load control** | - implementation with AMR meters<br>- implementation with additional HEMS<br>- offers a business field for an aggregator<br>- better solution than customer's spontaneous price-based DR |
| **Sharing the benefits** | - customers with electric heating contribute the whole system<br>- contradiction between the supplier's and the DSO's preferences<br>- discount in monthly fee or compensation per time |
| **System requirements** | - controllable load groups behind a button<br>- automatic compensation to the invoice<br>- activating the DR resources when getting a new customer or switching the supplier<br>- suitable for different customers |

Interviewees represented their organizations, so the answers to the questions were mostly formed by the general opinion of the organizations. Interestingly, even though the number of interviews was low and the company sizes of interviewees varied, their answers were notably similar. The analysis does not categorize opinions of different respondents.

The companies represented in the interviews were ordinary small- or mid-sized energy supplier companies whose customers live mostly on the area of the network company of the corporation. Biggest of the companies sells energy to around 100 000 usage places. Only one of the companies offered publicly a dynamically priced electricity contract in its assortment. It had around 200 customers with that kind of electricity contract. The other companies had also technical possibilities to offer a dynamically priced contract publicly but at this point they had only a few entrepreneur customers with that kind of contract.

The interviewees were asked if their companies buy small-scale production from their customers and how much work that requires from the companies. None of the companies advertised on their web sites buying electricity produced by their private customers but it revealed to be partly possible and some customers get compensation for their electricity fed to the grid. An interviewee stated that customer with selling contract does not keep the company any more busy than a traditional buying customer, after the contract details have been filled in the information system. This seems that DR contracts could work as easily after the common terms have been agreed and the necessary information about the customer is collected to the information system.

Overall, the interviewees regarded DR interesting but not the first issue to concentrate on in their businesses. It is no gold mine compared to other issues needing development considering the present customer structure. With present electricity prices there is no need to hurry with DR. If high price peaks (like 100 €/MWh hourly price in spot market) occur weekly, would the DR implementation start to bring some benefits. After five years the situation can be much more profitable for DR. Before that, bigger suppliers can take the lead with DR contracts since their marketing requires capital.

If one big market party starts to market the idea of DR to the wide customer mass, it will benefit the rest suppliers too, as well as the whole industry. Increasing customers' awareness of functionality of electricity market and the role of active customer would also grow their interest towards new type of electricity contracts. This far, the interviewees think that only forerunners, engineers and other enthusiasts would be interested in dynamic electricity contracts that involves some home automation.

One interviewee regarded DR challenging, since majority of their customers are using district heating and therefore the flexible capacity of their customers is minimal. Overall, interviewees considered houses with electrical heating the best customers to implement DR. However, all these customers should be tempted to make a new electricity contract to get the benefit from DR. The only problem is, that these customers with electrical heating usually uses already night-time electricity to warm up their storable electric heating. This does not leave much flexible potential for daytime even though all these customers would have an electricity contract supporting DR. Luckily, their flexibility potential can be utilized night-time. Usually the electricity heating does not need to be on all the night and the load hours can be optimized between 22-07 as well.

The most need for DR would be during mornings and afternoons when the consumption is high. The high consumption is not a problem for a supplier, but the same hours are typically also the most expensive. The most interesting issue in DR for the supplier is to move the consumption from an expensive daytime spot hour till a later hour.

## 5.3 Discussion of the themes

This sub-chapter opens the main themes categorized in the table 5.2. All the central findings from the interview answers are documented in here. The topics that rose in the conversations will be also reflected with the theory from the beginning of this study. Some ideas and key questions that rose from the discussion will be presented in this chapter, and recommendations to solve those will be tried to find in the next chapter *6. Demand response product implementation in customer interface*.

### 5.3.1 Need for standards

There are many stakeholders who operate in the framework of demand response. This leads to challenges for example in moving the time series information between several parties and systems. New stakeholders, like construction, aggregators and device manufacturers become interested in dealing with the metering data.

Based on the interviews, it seems that new standards, guidelines and common policies would help to combine the needs of DSO and the supplier, and a basis from authorities would contribute to create DR contracts. Some common principles and good agreements would be helpful to handle for example payment and on-off-switching disruptions. On the other hand, the interviewees doubted if regulations leave enough space to product differentiation between suppliers. The benefits of a supplier stays low if there are too strict preconditions for load control in *Terms of electricity sales*.

If load control is utilized with AMR meters, the DSO is involved in the steering by force since it owns the meters and delivers the control signals. When there are several suppliers with different load control principles operating in the network of a DSO, creates it a complicated situation to control the electricity of the right customers at the right time.

Therefore, decisions from the authorities might be needed to create a load control model for all DSO areas. A separate energy company might not have resources and interest to develop a technical solution that works with all its customers because, in turn, it can have customers on nearly one hundred DSO areas. A new legislation could build a base for load control implementation.

The interviewees were asked about their feelings about the supplier centric model and all of them were on its side. Under present discussion the supplier centric model means the situation where the supplier invoices the distribution together with the energy fee. When talking about the supplier centric model the first step to do is to make a decision to start to use it in the electricity market. Now the interviewees are waiting for ready standards to enable an automated distribution invoicing through the supplier. The process should work automatically with the metering data and message exchange coming from the DSO so that the supplier does not need to take care of the right distribution products on the bill.

When interviewing the representatives of electricity supplier companies they wished for unified distribution products. This would naturally help the distribution invoicing made by the supplier. As the network business is already highly regulated, could it therefore be possible to standardize the distribution tariffs as well?

The interviewees would be interested if the DSO would offer a DR service for the suppliers. It would lower the threshold to implement DR contracts. Surely, it will not be cheap or first thing in the DSO's interests, but it would ease the supplier switching process too. If the DSO made a load control contract with a customer group, the supplier would get the information when concluding a supply contract with that customer. With open interfaces the supplier could easily activate the load control possibility with already existing information about load capacity and control conditions and prices. A further functionality could be, for example, that the DSO cuts the consumption for a device group if the spot price rises over 100 €/MWh.

In this present situation suppliers' and DSOs' different targets are challenging to combine since they have built different business models based on their aims. Standards would equalize their goals and help to implement DR into both businesses. Sending a DR signal requires information message traffic between several operators and DSOs like presented before in figure 2.7. In the future, the datahub could ease that communication traffic if the load control requests also ran through the hub. The functionality may not be included in the first version of the datahub but in the second phase it can be possible. Now that there is no standardization there exists a great place for an aggregator to create business of DR operating between miscellaneous field of suppliers and DSOs as presented in figure 5.1. The work of the aggregator would naturally create some standards into the field of DR and load control when finding solutions to deliver the load control requests to the distributed mass of usage places.

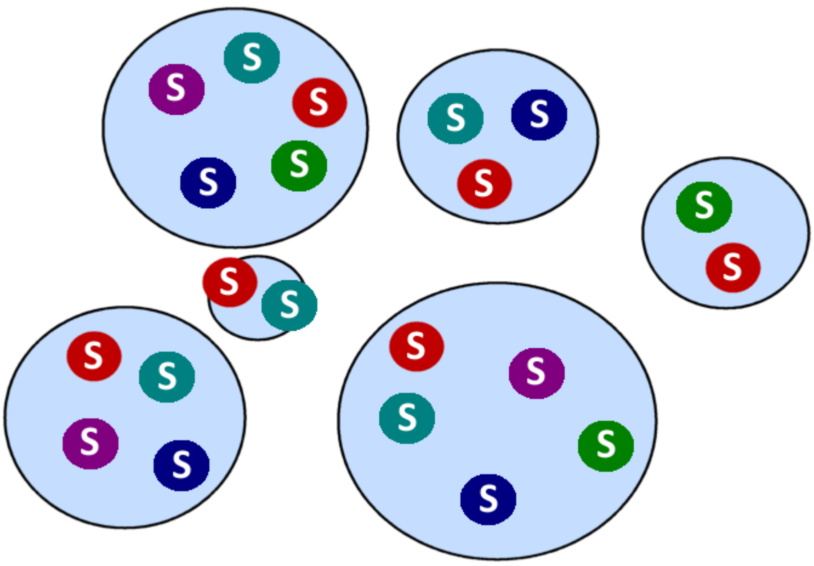


***Figure 5.1**. Supplier sells electricity in multiple DSO areas. The blue ellipses describe DSO areas and the spheres are usage places of different suppliers.*

### 5.3.2 The fairness of dynamic electricity price

The interviewees acknowledged that customers will not avoid expensive spot hours voluntary if it does not bring any benefit for them. Therefore, dynamically priced contract is the only option to make customers think about their consumption time based. If the customer pays his electricity usage based on the spot price, price peaks in the wholesale market can result very high costs to the customer during the peak hours if he happens to have several appliances on at the hour. Understandably, these surprises in the electricity bill may arise dissatisfaction among the customers.

Customers have enough worries and more interesting things to do without following the electricity price. Therefore, they appreciate the fixed-price and are ready to pay a bit higher bill to avoid the price risk. As pointed out before, electricity is cheap in Finland compared to most countries, so the electricity bill should increase significantly to make customers consider an alternative pricing for their everyday commodity.

Overall, the interviewees emphasized that choosing a dynamically priced electricity contract requires own home automation to utilize the cheaper spot hours automatically. Acquiring a suitable HEMS for dynamic pricing asks activity and awareness from the customer but would be easier way for a supplier to establish DR. On the system level the dynamic contract is easy to achieve and the companies represented in the interviews told having the technical readiness for this kind of contracts with their customers.

To get customers attention, the dynamic electricity contract should not generate any higher bills than fixed-price contracts. The interviewees stated that the wide customer mass chooses their electricity contract based on the price. Green values or web portals offering extra value will not compensate the electricity price if the customer thinks that the price exceeds the pain threshold. Correspondingly, the only benefit that dynamic pricing brings to the supplier too is the financial advantage through the contract pricing.

Literature and interviews both recognize the aspect that after the price has formed in the exchange, cutting the consumption will not benefit the supplier anymore. Therefore, active customers with dynamic contracts form a risk for the supplier. Customer-oriented decision to postpone the consumption will necessarily not hit the hour that would be the most favorable for the supplier.

Interviewees considered that as it happens already in the small scale, the suppliers can offer dynamic contracts beside fixed-price contracts that include load control in the future as well. New freezers and refrigerators might control themselves soon price-based too. Later in the future the customer (or his HEMS) could send the hourly load forecast for the coming day directly in the information system of the supplier.

It can be concluded that dynamic contract is outsourcing the DR for the customer and it is technically easy to implement for the supplier. As long as there is only a small customer group having it, it doesn't threat supplier's electricity procurement planning.

If the supplier sells a HEMS for a customer besides a dynamic contract the supplier can earn additional revenue. Nowadays, the group that is interested in following energy consumption is though marginal and, furthermore, the HEMS will benefit mainly the customers with electrical heating. Majority of the customers are not ready to pay for the HEMS even though it promises to lower the electricity bill during longer time span. The central advantages and disadvantages of dynamic pricing is shown in table 5.3.

***Table 5.3**. Pros and cons of dynamic pricing for customer and supplier.*

| | **Customer** | **Supplier** |
|---|---|---|
| **Benefits** | can lower electricity bill if customer has suitable loads | easy to put to use technically |
| **Challenges** | requires following the electricity prices (usually HEMS) | active customer makes consumption forecast difficult |

### 5.3.3 Alternatives for load control

The interviewees emphasized that DR would bring the most benefit if the supplier has the right to decrease customers' consumption when needed. Overall, supplier-oriented DR was regarded better solution than customer-oriented. This option would be more beneficial for the whole energy industry because this way the decision of load control can be made before the electricity price formation. Load control would lower the spot price if the decision of flexibility is made by the supplier in advance.

To become common, DR carried out by supplier's load control requires co-operation between the supplier and the DSO. As discussed, a simple load control can be carried out with AMR meters only, without need for extended HEMS. However, when using also HEMS, additional value can be created to the customer and the possibilities for the supplier to control the loads increase. There was discussion with the interviewees about both the alternatives.

If using DR utilized by AMR meters, the DSOs would have the actual implementation for the steering but they will receive the impulses for steering from suppliers with message exchange. The new AMR meters have a relay that enables load control for reserving electric heating. However, the interviewees reminded that deploying load control requires a coupling visit at the customer's home as the controlled load need to be connected to the relay physically. As it cannot be managed by pressing a button on the system level it will not be cheap either.

Positive and negative aspects were found in DR implementation with additional HEMS. Nowadays the appliances are too expensive compared to the achieved savings. The systems should be a profitable investment at least with longer time span. The interviewees saw it challenging to divide the costs of the appliances fair. Anyway, they regarded it possible that the supplier would pay the appliances and then it could combine the costs with the DR contract offered to customers. Preferably, the applications should be that multi-functioned that several suppliers could use the same system. Otherwise it becomes challenging if the customer switches his supplier and the systems need to be changed too. As the DSO has to manage its meters and systems anyway, the suppliers thought that DSO could possibly also take care of the HEMS. The DSO could naturally share the costs somehow with the supplier.

Whoever is paying the HEMS solution in the first hand, the costs will be delivered to the customer at the end. And the interviewees pointed out that the customers are not ready to pay any higher electricity bill only because of the joy to get the appliances. Only a marginal customer segment would be interested in following the information they offer about electricity usage.

Considering the interviews and the theory, the customers regard the direct control made by the supplier as a more acceptable solution than a spot priced contract to carry out DR. Simplified, the concept would work utilizing load control by cutting electricity for certain loads when a defined pain threshold for energy price is crossed on that hour. The central advantages and disadvantages of load control is shown in table 5.4.

***Table 5.4**. Pros and cons of load control for customer and supplier.*

| | **Customer** | **Supplier** |
|---|---|---|
| **Benefits** | discount in electricity bill if customer has suitable loads | profit optimization through electricity procurement |
| **Challenges** | change in the availability of the everyday commodity | execution requires expensive appliances and coupling visits |

At this point, the potential customer segment for load control is marginal consisting mainly of houses with electric heating. Nonetheless, load control should be taken in account in new houses in the construction phase. Later, when own production and electric cars generalize this option becomes profitable in larger scale. When the present AMR meters need to be replaced to next generation meters is there a good chance to make advanced DR couplings together with the installation of them. Before that there is left the option to control reserving electric heating that is already coupled to the AMR meters. Next step could be to connect direct electric heating behind the load control relay but there has to be solved how to bypass the present thermostat control.

### 5.3.4 Sharing the benefits

The customer naturally needs incentives for letting the supplier to control his loads. The incentive can be a discount in the monthly energy fee or it can be paid based on the times when the supplier uses his right to control the loads. The interviewees emphasized that dividing the saving achieved by DR between the customer and the supplier half and half would be the fairest situation. When using load control, they preferred the solution where compensation would be paid per time when the supplier uses his right to cut the electricity for a control group. If the customer gets a fixed compensation in his monthly fee it will not benefit the supplier if there is less high price peaks.

As mentioned in chapter *5.3.2 The fairness of dynamic electricity price* the wide customer mass appreciate cheap electricity bills the most. Reflecting that view, a discount in monthly fee would be the most attractive reason to switch to DR contract. For example, an interviewee told about good experiences about former power tariff contracts that were used in the 1980s when the supply and distribution was businesses of the same company. A customer group with electrical heating had a power tariff contract where they paid a fixed monthly fee, and with higher capacity they got more discount. A few times during a winter the electricity company used the right to limit its customers' electricity usage. It did not bring any harm to the customers but kept the energy procurement costs moderate. The positive feedback of that arrangement would encourage to implement load control contracts to support DR.

There was discussion about how much is suitable compensation for the customer for load control. For example, if the customer would get 1 € for every cut and there were ten cuts in a year the customer would earn a 10 € compensation per year. As the electricity bill for a customer with electrical heating can be over 2000 € per year, a considerable compensation starts probably from 100 €.

The interviewees regarded the customers with electric heating as the first potential customer segment for DR. There are plenty of those in Finland, but how to make DR contracts attractive for all of them? If all the customers with electric heating will cut their consumption on a peak hour, will the spot price for the rest energy on the same hour also stay lower. The achieved saving can be calculated but how this information should be brought up to the customers? The customers with electric heating contribute the whole system because their actions affect the price formation in the exchange. The interviewees regarded the sharing of the benefits and the amount of incentives challenging because it is hard to define who deserves compensation.

Summarized, the suppliers support more the compensation per time. The customers appreciate fixed price so that the size of electricity bill can be forecasted. The situation can be compared to phone bills, where bigger and even more expensive packets that "include all" are popular. A pleasant option for a customer might be 20% discount in his yearly invoicing. There the discount becomes bigger for those with bigger capacity and bigger bills. Another question is if all the customers with the same capacity are equal to the supplier or does the sort of the load make difference. In any case, the opinions about pricing might change when the volatility of electricity price increases in the future and there becomes more and more favorable peak hours to use load control.

### 5.3.5 System requirements and technical functionalities

When there was discussion in the interviews about supplier centric model the interviewees shared some thoughts about requirements for information systems. Distribution invoicing by the supplier will set some conditions for invoicing procedures but DR will bring even more variables for customer and metering data management, and invoicing as well. However, the interviewees counted on the information systems of today.

Overall, the interviewees stated that technical solutions of the systems have to be simple, cost-effective and suitable for different customers. The customer can switch his supplier so it has to be easy for the supplier to activate the DR resources.

If the customer had a load control contract and receives compensation based on the times of control there has to be an automatic compensation model for invoicing, which does not require any manual work by the supplier. An interviewee told about experiences when they tried to invoice their customers' distribution together with the energy bill some years ago. The practice stayed on a trial level because it was too complicated to feed the different distribution products in their own systems.

The interviewees summarized that best implementation for load control would be a load of 1 MW (or its multiples) behind a button that can be switched off if necessary. The load could be a group of customers devices which mean load would be 1 MW. However, with present one-way data transfer the supplier cannot be sure how much the actual consumption will fall with that button if a significant amount of the devices in that group are already turned off. For example, when procuring the electricity for the coming day, the supplier could set the loads behind the button off on a certain hour if the spot price is high. If the supplier avoids buying already 1 MW of electricity for 500 €/MWh the saving is considerable and the saving could be shared somehow with the customer. Already, when the spot price for the electricity rises to 120 €/MWh and in that case the supplier buys in total 10 MWh less energy than planned will some saving be realized. This functionality should also work automatically if needed.

The interviewees thought about how to know when it is profitable to use load control. Besides day-ahead electricity procurement planning, extra profit can be obtained with DR by using it for trading in imbalance market. The need for imbalance power is not known before the delivery hour but if the price for balance power rises high, significant profit can be achieved with load control. Then someone (or an algorithm) should actively offer electricity by cutting the consumption for Fingrid's imbalance market. If Fingrid buys the offer, then the consumption has to decrease in 15 minutes which has to be taken in account in customer interface.

Finally, the interviewees listed some central information that need to be collected from the customer when making a DR contract that includes agreement for load control. The basic information includes at least how much controllable capacity the customer does have and how the loads can be controlled, i.e. what the loads are and do they have some restrictions for control. The small-scale production is also important to know because it affects the supplier's consumption forecast. Finally, it has to be clear which loads and phases are connected to which relays behind the electricity meter or HEMS so the supplier knows where to address the load control message.

After all, additional information about customer's loads is needed in all the situations presented in chapter *3.3 Processes related to electricity contract*. When concluding a contract with a new customer the information for load control shall be collected. After that, when switching the supplier it would be handy if the customer information would transfer directly to the next supplier with message exchange. When moving, the customer information has to be updated. Finally, the information related to load control affects the invoicing process.

# 6. DEMAND RESPONSE PRODUCT IMPLEMENTATION IN CUSTOMER INTERFACE

Implementing DR requires product design, system development and standardized interfaces to enable a convenient and automated operating between a supplier, a customer and other stakeholders. Research is needed to develop the revenue generation model. The customer needs to be taken into account in marketing and offering incentives. With communication the wide customer mass can get informed about the required change in their everyday life electricity usage. Branding the demand response products right the consumers can also get interested in new electricity contracts which benefit both the customer and the supplier.

This chapter will point out the things to consider when planning the DR products, based on the supplier interviews and the requirements and outcomes achieved in previous chapters. The focus is to define the restrictions for the contractual implementation and find features that need development on the system level and in message exchange. Suggestions for load control compensation and value creation for both the customer and supplier are also given.

There are many options to build electricity contract products utilizing DR. Things to consider are for example what kind of contracts are profitable for the electricity supplier and on what terms the customers are willing to conclude those contracts. How the present legislation affects DR contracts? What kind of incentives are needed in order to let the supplier to control customers' loads? Which stakeholders are doing co-operation in load control and who are in relationship with the customer? What information need to be collected about the usage places?

Findings to these questions will be spoken out in this chapter. Some estimates will be given about the time span when the different alternatives could be established. In the first sub-chapter will be discussed the problems and possibilities related to the general framework of DR contracts, referring the chapter *3.1 Legislation in Finland and electricity metering*. The second sub-chapter will compare the choices the supplier can make in offering DR contracts for a customer. The third sub-chapter explains the processes related to the conclusion of a DR contract and gives suggestions to develop the information flows during the supply, referring to the chapter *3.3 Processes related to electricity contracts*. Finally, there is left maintenance of the relationship between the customer and the supplier. The last sub-chapter describes how the everyday usage of electricity and the relationship to the supplier develops when moving to more flexible consumption. An implementation example for a DR pioneer is presented shortly.

## 6.1 Development of the framework

The field of electricity distribution and energy business is widely regulated which set certain limits for the electricity sale. The legislation and guidelines affecting in the framework was introduced in chapter *3.1 Legislation in Finland and electricity metering*. There are also many unsolved issues on the way of DR contracts that are yet no-one's-business. New interfaces between stakeholders will develop as well, which raises the question about sharing the responsibilities in different situations. When there are several suppliers with different load control principles operating in the network of a DSO, creates it a complicated situation to cut the electricity from the right control group at the right time. If there was a commonly agreed protocol how to handle these load control requests from the supplier, would the information flow smoothly automatically. All these factors ask for common guidelines.

### 6.1.1 Restrictions and possibilities of legislation

The preconditions for demand response depend on several different decrees which no one is coordinating from the DR point of view. An own decree for DR might solve the unclear situation because nowadays all the electricity market parties think about DR that it is not on their responsibility. An expansion about DR to *Guideline for AMR metering* or *Terms of electricity sales* could do the same profit.

For the suppliers, it is mandatory to list all electricity contract types with their characteristics on Energy Authority's web site, which is a good place to compare the contract prices equally. Also, that way the customers could easily find new DR contracts. When searching for the contracts, the user needs to enter i.a. his distribution tariff and choose the type of the contract. Present alternatives for the contract type are *Indefinitely valid*, *One year fixed term, Two years fixed term, Other fixed terms* and *Exchange bound*. The *Exchange bound* option includes already dynamic price contracts but another alternative for contracts including load control would be necessary. Of course, contracts including load control can be indefinitely valid or valid for a fixed term, but an own option for contracts that include incentives for load control should be pointed out in here. The type of contract could be just "Load control" and the category could arrange the contracts with different algorithm than the traditional contracts to show the characteristics of those contracts in better light. An upgraded view of the official site is presented in figure 6.1.

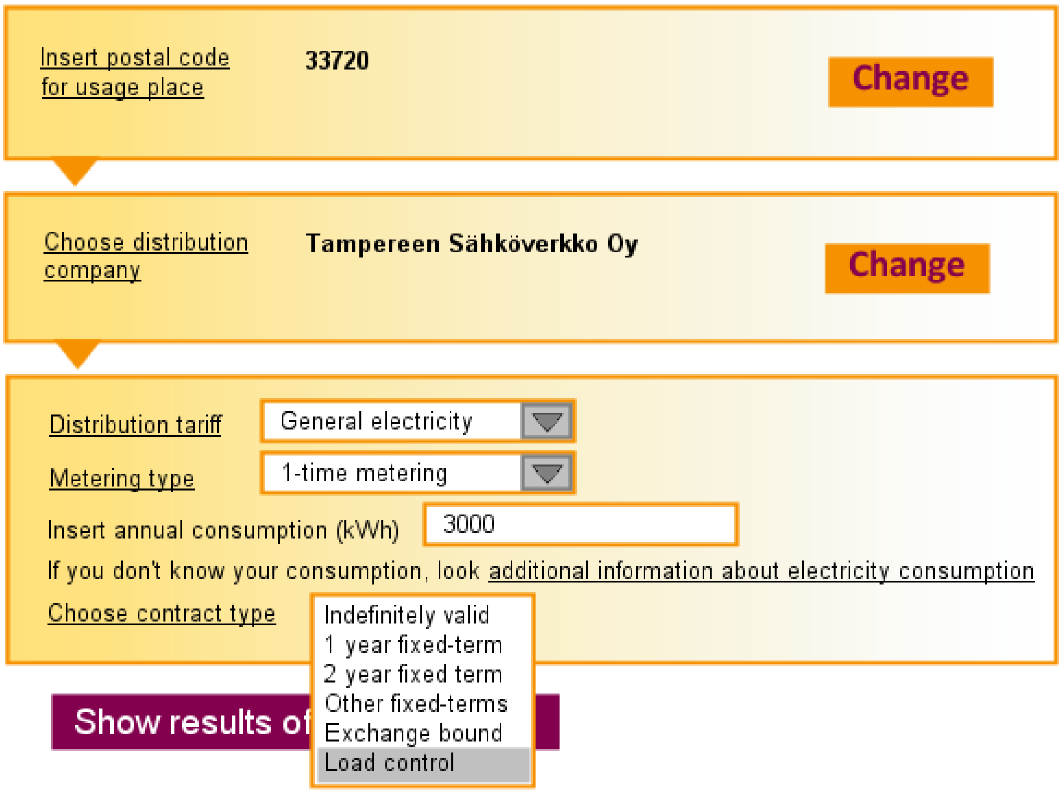


***Figure 6.1.*** *An upgraded view from Energy Authority's www.sahkonhinta.fi page when choosing the contract type. (After, Energy Authority 2014c)*

As pointed out before, the *Terms of electricity sales* and *Terms of Network Service* set borders for load control so that the availability of electricity shall not be restricted more than 5 hours per day and 1,5 hours at once. These limits are a good starting point when designing new contracts with DR and yet there is no critical need to update these. If the maximum limiting time for electricity is 1,5 hours at once is it safe to use even freezers and refrigerators as a controllable load. Customers have probably noticed that the temperature of those will not reach rising too high even during occasional blackouts. If the maximum restriction for availability of electricity is five hours per day, then the households will stay warm and the level of comfort will not suffer. However, if the supplier can control several device groups at a customer's usage place the combined amount of restricted hours can go over five and the reading of the terms should enable that.

When talking about controlling the availability of electricity, it is natural to move discussion to the control devices. The technic is not established yet so it is hard to buy customer's trust since the entirety is not simple enough. Some parties also hesitate with the new operating models and think that it is not beneficial to take any actions before all the alternatives are researched carefully, to avoid useless investments. Environment of smart and flexible electricity market offers a new business segment for several application manufacturers. This leads to question about standardizing the installation of the devices for home automation and energy metering. New service providers should pass a qualification and registration process to ensure the compatibility of their systems and interfaces. This way the connection with an AMR meter could be easily established and the customers can rely on the functionalities of different alternatives for home automation and energy management.

For load control made by a separate HEMS device, standardized requirements for HEMS appliances would be worthwhile. Electricity suppliers would be happy to utilize the HEMS that the customer already has in his apartment. If the customer buys or gets a device that is suitable for the electricity contract with his present supplier and after the contraction period changes his supplier, it will be beneficial for all the parties if the same device can be utilized in future as well. If the new supplier had for example different device groups for load control, a coupling visit might be needed again. But in most cases there might be no need for a new installation visit if the new supplier could only remotely update his software in the old HEMS. The customer would only need to learn to use the new user interface of the system if a touch screen UI is used. What need to be decided are i.a. the data transfer protocol and the couplings for the standards. However, the HEMS device shall not be specified in this study. Load control can be carried out by the AMR meters as another option. The present AMR meters enable simple load control but at the latest the new generation of AMR meters will be enough for load control.

New houses are being built all the time and DR would be most beneficial to take in account in the design and construction phase. Therefore, the construction decrees and energy efficiency decrees should give guidance considering DR and load control readiness. The electricity design for a building should be done so that loads suitable for load control can be coupled behind a DR-relay. Although the coupling is done it does not involve concluding a load control contract in the building but it leaves an option for that. Unfortunately, writing a guidance for electricity design is not that clear because the implementation with HEMS device is as good solution for the next coming years.

### 6.1.2 Sharing the responsibility

Referring to the interviews and general opinion of the stakeholders in the framework, none of the parties is particularly eager to design and invest on the load control infrastructure. Most interesting DR is for the suppliers because it is most useful for profit optimization in their business. Especially small suppliers regard the load control too hard and expensive to implement on the dispersed mass of usage places. Consequently, an aggregator is warmly welcome to the business field to manage the usage places on several DSO areas.

Among legislation, DSO is involved to deliver a metering device to the usage place in order to enable load control service. The legislation will not define the load control executing itself as network business, but Energy Authority could consider changing its opinion about that. The DSO should have an incentive to develop load control concept. The regulation model pushes DSO to invest on strengthening the grid but part of that investing should be encouraged to be directed to the load control service. If DSO starts to build a load control model in larger scale, there will be a need to separate it from the regular business. There has to be considered DSO's operations defined by legislation, i.a. obligation to treat all the customers equally.

The interviewees would be pleased to get a load control service provided by the DSO and they regarded it much better option than if a third party would pop up to arrange that. If a third party would create a new interface with a customer would it be too much since already nowadays it is hard to understand that electricity sale and distribution is provided by different companies.

The DSO might be interested in participating the developing of load control infrastructure if it will be economical for it. However, DSO's and supplier's interests to control loads will probably not occur on the same hour. During a cheap spot hour the supplier wishes to supply electricity as much as possible but at the same time the capacity of the network can reach its limit. Then the DSO in turn wishes to restrict the delivery if there comes shortage for power. This contradiction need to be solved so that DSO and the supplier can both restrict the availability of electricity when they need it the most. The preferences of both parties need to be taken into account so that there will not rise a need to create parallel implementations for load control, because it would be the least economic situation.

If the supplier has based its electricity procurement on the situation where load control is used and for some reason the DSO will not cut electricity feeding for a particular group, there need to be an agreement that DSO will compensate the loss for the supplier. If the electricity could not be cut because of customer's actions, i.a. unauthorized couplings, wishes the supplier charge DSO and the DSO could charge the customer. There can occur also a data transfer failure before the control signal reaches the customer's AMR meter and then the metering service provider could be the one paying for the loss.

If the load control is carried out by a HEMS device there still exist the same uncertainty in delivering the load control signal. Although the DSO is not involved in the process, the delivering of the control request can depend for example of the internet connection because the HEMS requires usually a WLAN. If there are some disruptions in the internet connection and the planned controls cannot be executed because of that there need to be a contract that specifies which party is again responsible for the financial losses.

## 6.2 Alternatives for the electricity contract

Common electricity market starts to create increasingly more competition between the suppliers. Soon the cheap electricity price is not the only way to keep the customers, and the supplier needs to offer tempting alternatives for electricity contracts. There DR is involved to create new revenue streams. Conspicuousness of the supplier helps to acquire customers so that potential customers with suitable loads for load control will find the supplier. When bigger suppliers advertise their DR solutions will it benefit also the smaller parties in the market.

There are already several dynamic electricity contracts that leave the load control on customer's responsibility. Demand for these kind of contracts seem to increase and within next five years residential DR will be carried out with these contracts. After ten years default contract might be a contract where the supplier controls customers' loads. Then the framework is probably advanced, high spot prices occur weekly or even daily and there will be more and better batteries available. This second alternative is better option because the consumption can be forecasted a day before the operational hour and there consumer flexibility can be utilized in the spot market.

### 6.2.1 Finding the customers

The supplier should find a way to get information about consumers with potential loads, appliances and controls and with interest for DR. The customers who have night-time electricity contract are a group that is ready for DR because they have big loads connected to a relay that switches their reserving electric heating and boilers on after 22:00.

Another group for DR could be customers with direct electric heating even though the potential is not as flexible as reserving electric heating. Today usage places with direct electric heating are not separated in the supplier's information system. The direct electric heating is usually controlled with thermostats and that controlling should be changed to go through a relay that the supplier can control. Even if the supplier is not eager to make that coupling yet the information about these existing customers would be useful to collect. The supplier can make good estimation that it's private customers that have relatively big electricity bill (>15 MWh per year) and live in a detached house (based on the address of the usage place) have direct electric heating. For example, those customers can be contacted by e-mail and asked to mark their load capacity in supplier's web portal. If the supplier is not willing to do the work it can give a commission for an aggregator to make the same investigations. Many other load analyzes can be also made based on the consumption information. In any case, it has to be kept in mind that customer information is confidential and shall not be submitted to a third party.

To find potential customers for DR contracts outside of supplier's existing customers DSO could be the party to help. DSO could do the same investigations about it's customers' electricity consumption. For example, depending on the implementation of the customer module of the datahub the DSO could collect and store the heating type and annual consumption estimate of it's usage places into the datahub. If suppliers can access the customer basic information of suitable usage places the suppliers could contact the customers. DSO could be the party even to categorize suitable load control groups among it's customers. Of course, DSO does not have that great interest to do the work from it's business perspective. In order to do the work it should have strong incentives which could e.g. rise it's allowed profit margin.

The first step to get new customers for DR would be contacting supplier's suitable existing customers. Advertising can be sent in a regular customer letter or with an electricity bill. The advertisement could inform the customers about different devices' typical consumption, available dynamic electricity contract, electricity market and DR. The customers can be asked to indicate their heating solution and bigger electric appliances in a web portal. A lottery can be made within the customers who have left their information but probably only the forerunner customers who are interested in DR will give their load information. Also, if the supplier gives a project to a telecenter to market their electricity contracts the supplier could easily add that the calling project includes asking about the heating type of the reached person.

When information about some customers' loads and their controllability have been collected, the information system of the supplier need to be updated to handle more specific usage place information and the data from the web portal can be transferred there. In the customer information system could be a field to indicate capacity, type, connection to an AMR meter (connected to a relay / a relay exists / no relay) and connection to a HEMS (connected to a relay / a relay exists / no relay). When the datahub will be taken in use the collected information can be transferred there as well. If a DSO is collecting the information there could be an incentive for a DSO who fills customer load information in the hub. For example, the collected information can be categorized as follows in table 6.1.

***Table 6.1****. Information about customer's loads in supplier's information system.*

| **Capacity (kW)** | **Type** | **Status** | **Connection to an AMR meter** | **Connection to a HEMS** |
|---|---|---|---|---|
| < 1<br>1-2<br>2-5<br>5-10<br>> 10 | heating<br>fridge<br>heat pump<br>electric car<br>other | always on<br>occasionally<br>x hours/day<br>thermostat<br>other | behind relay<br>relay exists<br>no relay | behind relay<br>relay exists<br>no relay |

If a supplier wishes to get flexible small-scale consumers living in block houses then the supplier can make an electricity contract e.g. with a student housing company. The electricity is usually included to the rent so the consumer does not have an own electricity contract. The supplier gets several consumers with only one contract. A suggestion about implementation is given in the last sub-chapter *6.4.2 Case Mikontalo.* Marketing and increasing consumers' awareness of electricity market might also help to get consumers interested in DR, which will be discussed more in chapter *6.4 Improving the customer relationship*.

### 6.2.2 Dynamically priced contract

In price based demand response the customer can decrease his electricity bill by shifting his consumption to the cheaper spot hours voluntary without supplier's control request. With this indirect control of the loads there does not have to be any separate compensation for flexibility on the bill.

Today (10.11.2014) there are 24 different electricity contracts with dynamic price on Energy Authority's page, *www.sahkonhinta.fi*. Among the interviewees there is demand for spot based pricing. In smaller scale that kind of contract is beneficial to all parties even though it cannot be the future's solution for DR. However, this is the option to utilize DR already tomorrow. There is plenty of alternatives for interested forerunner customers to control own consumption with ready setups or even build an own solution for energy consumption management. One alternative was presented already in chapter *4.4 Load control*. More and more home appliances have intelligence and for example washing machine can be adjusted to start on the cheapest spot hour. The machine can choose the optimal hour automatically or the user can choose the starting time when looking at hour prices by himself.

A commercialized example where supplier is offering a HEMS is Fortum Fiksu, where Fortum sells a HEMS solution manufactured by There. When buying the product the customer concludes also a dynamic electricity contract with Fortum at the same time. Installation by an electrician is also included into this turnkey product. Even though the customer concludes a dynamic electricity contract the implementation includes load control. With the HEMS the supplier can control i.a. customer's reserving electric heating to switch on the cheapest spot hours. (Fortum 2014)

Dynamic contracts are a technically easy alternative for the supplier but it leaves the price risk for the supplier if the amount of active customers increases significantly. The pricing model where customers pay for their energy the spot price and the supplier's marginal added to that makes the supplier's balance management harder. The active customers should be turned into a resource. Fortum Fiksu is an example how load control benefit both the supplier and the customer. Furthermore, the supplier can price the hours differently than the constant marginal added to the spot price. However, if the supplier prices the hours with an own algorithm and the customer adjusts his consumption based on Elspot FIN can the customer regard the unpredictable situation unfair.

There are many alternatives to price the hours in dynamic electricity contract. For example, a spot priced or even fixed price contract can include occasional hours that are priced differently. If the supplier will price one or two extra expensive hours in a week can it warn the customer about those. The interviewees suspected that this kind of pricing model would not be interesting but when asking the same question from students they can imagine it as a possible future's alternative.

As mentioned before, using spot priced contracts can increase the consumption peaks in the network. The interviewees stated that iterative feedback based on the spot price can also have harmful effects on the electricity market and price formation mechanism. The actions of active customers should be estimated with help of psychology combined with mathematical statistics and economics to make dynamic pricing beneficial alternative for all the parties.

### 6.2.3 Contract including load control

In contract including load control the supplier takes care of the flexibility of the consumption. In light version of direct load control the customer does not even notice the control of his loads, if the supplier is controlling for example only the heating. Already existing night-time electricity contract is an example agreement with fixed control schedule. There are several alternatives to compensate the supplier's right to control the loads, as well as for the technical implementation. The incentives and solutions can be used also parallel so there are plenty of issues to decide and agree.

Even though the customer lets the supplier to control his loads the customer wishes to keep the last word on the controls. As for the supplier, it wishes to get some estimation about how many of its controls will be executed so that it can plan its electricity procurement for the coming day and use the household flexibility potential in the spot market. Default setting for the controls could be *automatic* where the customer does not need to care about the controls and the supplier will control the electricity feeding as agreed. The agreement is usually done so that the supplier's actions are beneficial for the customer as well. In the automatic mode the supplier's controls can be requests, or more like commands. The most acceptable choice would be daily sent control requests within agreed borders for the coming day. The customer can view the suggested controls in a customer portal and deny them if needed by switching to *customer* mode. Whenever the customer wishes to decide about the controlled hours by himself he can use the customer mode.

In order to motivate the customer to accept the supplier's load controls, a bonus arrangement can be taken in use. The customer will achieve higher bonus levels in the compensation if he stays only in the automatic mode of the controls. If he denies enough controls he will lose his bonuses for a certain time period.

A load control contract need to define the agreements considering both the load control utilization and the calculation for monetary compensation. This information will set boundary conditions for the load control operations by defining a maximum amount of load control operations during a certain time period. This means that once this limit is reached, consumer's loads cannot longer be exposed to load control during the time period in question.

As mentioned before, the customers are not eager to carry the price risk and they favor a fixed price contract for a fixed time period. Considering this, a load control contract could have a monthly fee and energy fee that are cheaper than the fees in a traditional electricity contract but with the contract the customer lets the supplier to control a device group *x* times within a time period. Another option is more expensive monthly fee and energy fee but the customer will get compensation based on the executed controls. The interviewees preferred the second option and it could be the choice in the near future when there is no guarantee that high price peaks will occur.

A supplier would like to base the compensation amount based on the actual achieved saving. For example, the supplier can use the option to use load control if the spot price rises over 90 €/MWh. Let's assume that a supplier has 1000 customers with load control contract who has agreed about load control with their heating and the supplier will divide 50% of the saving for the customer. The generated saving for a customer and a supplier is shown in table 6.2.

***Table 6.2****. An example for a reason how to divide the saving to customers from a controlled hour.*

| **Elspot FIN** | **Customers** | **Average load** | **Saved energy** | **Saved money** | **Saving per customer** |
|---|---|---|---|---|---|
| 90 €/MWh | 1000 | 2 kW | 2 MWh | 120 €/MWh | 0,9 € |

Among Nord Pool Spot, Elspot FIN was only 15 hours over 90 €/MWh within gone year (10.11.2013-10.11.2014). If the load control was used all the fifteen times per year the saving for the customer stays under 20 euros. If that high price peaks would occur weekly, would the customer get a compensation of around 50 euros into his annual electricity bill. A customer with low annual energy consumption might pay around 300 euros per year for his electricity in total so for him the compensation could be pleasant. However, the customers having the potential loads to control, like electrical heating, can have ten times bigger annual electricity consumption and even the compensation of 50 euros will not be considerable on their bill. Therefore, with this compensation model the load control contract has to include more devices or more controlled hours.

The supplier can use the customer flexibility potential also for Elbas market when sending separate control requests for the next hour. There the supplier needs to count on realized cutting of consumption. There has to be an automated checking that these additional requests together with the control schedule made already day before will not exceed the borders agreed in the contract.

The unit for the control can differ from one hour if the flexibility is used for example in reserve market. There has to be kept in mind that the restriction for one control period is 1,5 hours in the *Terms of electricity sale*. For the reserve market, cutting the electricity for a specific group already for shorter time will be useful. However, there the cutting of the consumption has to happen fast so there is no time for the customer to hesitate with denying the control request. This sudden control request can disturb the customer more, but since the prices in reserve market are much higher than in spot market, can the supplier also give the customer higher compensation with “fast controls”.

There has been already pilot load control projects where the supplier has controlled the heating of a customer group. For example, related to SGEM program, Empower IM together with Oulun Energia put a pilot in practice by controlling floor heating with AMR meters. The infrastructure was built in two new block houses consisting of 23 apartments. The customers could prevent controls made by the supplier if they defined the control schedule by themselves, but they did not get any compensation for the flexibility. However, the housing comfortable level of the customers did not suffer and the acceptance was good. The implementation of the first electricity contracts including load control could be as simple as in this example.

On the next pages will be presented a suggestion for a modern electricity contract and an electricity bill generated based on the contract. On the contract page figure 6.2 shows some choices for the customer to make and on the bill in figure 6.3 can be seen the effects of the choices of the example customer. All the numbers are reference values indicating the right magnitude.

**Energy Company Oy Ab**

*Personalize your electricity contract*

*Achieve savings where it is most profitable for you!*

Choose the default contract to conclude a traditional electricity contract or change the energy fee or add load controls if you want to. If choices differ from the default, installation costs are added. Contract period is 2 years.

| **Monthly fee** | **5 euros** | *possible control with electricity meter or own home automation* |
|---|---|---|
| | 30 euros | *includes a home automation box* |

| **Energy fee (kWh)** | **6 cents** | |
|---|---|---|
| | spot + 1 cent | |
| | 5 c/8 cents | *daily expensive hours 7-9 and 16-20* |
| | 5 c/5 euros | *includes max. 100 expensive hours per year, the hours will be informed in advance* |

| **Load control** | **none** | |
|---|---|---|
| | Group 1 | *specify group settings below* |
| | Group 2 | *you can add as many control groups as you wish up to 5 groups* |
| | Group n | |

Load control options

| **Description** | **Average power (kW)** | **Load status** | **Control borders** | **Allow fast controls** |
|---|---|---|---|---|
| reserving electric heating<br>direct electric heating<br>fridge<br>household device<br>other* | 0,5<br>1<br>2<br>5<br>10 | always on<br>thermostat control<br>other control*<br>random | 5h/day<br>1h/day<br>2h/week | yes<br>no |

Load control compensation depends on chosen loads and their characteristics. When choosing “other” you can fill in extra information in the next phase. As default, controls are known day before and denying the controls is possible in the “customer” control mode. One control block lasts one hour. The longer you stay in “automatic” control mode, the more bonus points you will get. Read more about the bonus levels here.

So-called fast controls offer higher compensation and they will cut the consumption for the device group immediately. There the control period can be also shorter than 1 hour.

***Figure 6.2** The possible choices when making a modern electricity contract.*

**Energy Company Oy Ab**

**CONSUMPTION INVOICE**

**Usage place 7474741, Peltotie 6**

**Billing period 1.9.-31.10.2014**

| | | |
|---|---|---|
| Monthly fee | 10 € | (*home automation box not included)* |
| Energy fee (3941 kWh) | 217,20 € | (*spot-tariff)* |
| Group 1 | -36,80 € | |
| Group 2 | -2,40 € | |
| **Together** | **178,00 €** | |
| Cumulated annual saving | 169,03 € | |

Analyzed controls:

| **Group 1** | **Amount** | **á compensation** | **Cumulated saving** |
|---|---|---|---|
| Spot-controls | 87 | 0,4 € | 34,80 € |
| Fast controls | 2 | 1 € | 2,00 € |

| **Group 2** | **Amount** | **á compensation** | **Cumulated saving** |
|---|---|---|---|
| Spot-controls | 17 | 0,3 € | 5,10 € |
| Fast controls | 4 | 0,6 € | 2,40 € |

Group settings:

| **Description** | **Average power (kW)** | **Load status** | **Control borders** | **Allow fast controls** |
|---|---|---|---|---|
| **Group 1** | | | | |
| direct electric heating | 1 kW | other control | 5h/day | yes |
| **Group 2** | | | | |
| fridge | 0,5 kW | always on | 1h/day | yes |

*When lowering your room temperature by 1 °C will your electricity bill decrease 5 %. Additionally, your body uses more energy when staying in colder room so you may lose weight.*

***Figure 6.3*** *The bill for a modern electricity contract.*

## 6.3 Information in concluding of contract and during supply

The conclusion of contract includes plenty of information exchange between the market parties. If the contract requires load control some physical couplings at the usage place are needed. In any case, concluding the contract follows the common processes introduced in chapter *3.3 Processes related to electricity contracts*. The information collected from the electricity usage places and customers increases when using DR and it need to be transmitted in these processes and saved to the information systems in the future.

When concluding the electricity contract that allows the supplier to control loads, the customer needs to tell what kind of loads he has in his usage place. In practice, he may need to check from a ready list the loads and capacities that he has, as for example in table 6.1. The collected information would be transmitted to the DSO and to the potential next supplier (in case of switching supplier) with message exchange as additional fields in the present messages.

### 6.3.1 Information exchange in concluding of contract

The present processes related to electricity contracts transmit customer information between the suppliers and the DSOs. Electricity market information exchange ensures that the information is transmitted along the procedure when concluding a new contract, switching the supplier and moving. The same processes need to be able to handle also contracts that include load control.

The time borders that the processes set in *Message exchange procedural instructions* are enough also in the future even if some coupling visits need to be done. When concluding a contract with a new supplier and if the user's site requires metering changes, the notice from the supplier to the DSO must be received at least 21 days before the start of the contract.

SGEM report D 4.6.8 *Study of customer, contract and product management related processes* (Joensuu & al. 2013) described the most significant interactions between the electricity supplier and the customer during the DR contract process. The study discussed how the customer chooses the most suitable DR product from the supplier’s offering and the customer will give the supplier information that is valuable considering DR. The report pointed out also in which modules in supplier’s information systems the needed information can be saved and used.

The process of concluding a new electricity contract starts when the new supplier sends Z03 message to the DSO, after the supplier has identified the customer. The process flow and the message Z03 clarification was found in appendices A and B. Here, in table 6.3 is showed example for additional information into the message Z03 sent from the new supplier to the DSO of the metering point. The type of the load, i.a. heat pump or sauna stove, need to be chosen from a ready list. Suggestion for a list is introduced in next sub-chapter.

***Table 6.3**. Additional information in message starting the new contract process.*

| **Z03 Additional information** | |
|---|---|
| Load capacity (kW) | < 1<br>1-2<br>2-5<br>5-10<br>> 10 |
| Load type | heating<br>fridge<br>heat pump<br>electric car<br>other |
| Connection to a relay | connected to AMR meter<br>connected to customer’s HEMS<br>connected to supplier’s HEMS |
| Basic controls (on/off) | plugged off<br>occasionally<br>x hours/day<br>thermostat<br>other |

The same additional information as listed in table 6.3 could be included to the Z04 message that the DSO sends to the new supplier later in the same process when getting the confirmation to start the supply. That way the new suppler gets the possible old information from the usage place and it can be compared to the new one given by the customer. The process of switching the supplier follows mostly the process of new supplier. In case of switching supplier the information about load connection to a HEMS is maybe the most interesting field. If the customer has a HEMS and switches his supplier the owner of the HEMS is probably the customer himself, but the field gives a good ensuring about the owner. If a customer concludes a first contract that allows the supplier to control his loads the contract might include buying the HEMS device with monthly fee. Contracts that are sold with HEMS devices are profitable to make for fixed period and the device is paid back when the contract period ends.

When concluding the contract need to be agreed the borders within the loads are acceptable to control. The borders for contract are saved in the customer information system (in a special DR module) and the borders need to be checked when executing the actual controls or there need to be a warning if the control times are going over the agreed in a time span.

### 6.3.2 Information exchange during the supply

After the contract is concluded there is left the regular information exchange during the customer relationship. If AMR based load control is used the invoicing process includes information about controlled hours that may give possible compensation to customer. Also the actual control requests need to be transmitted to the control device in customer's usage place. Standardized interfaces between the systems are necessary to enable a fluent and automatic operational chain from the supplier to the customer.

If load control is carried out by supplier's own device the DSO is not involved in the load control. The communication between the supplier's information system and the customer's HEMS device can use whatever protocol the supplier wants. If the load control is carried out by the AMR meter is the DSO the party delivering the actual control requests. The load control request can be transmitted with new load control messages. Empower IM has developed messages sent between the supplier and DSO and message information related to load control process can be found in SGEM report *Load control messages* (Tervo & al. 2014). The load control message includes several elements, and one of them is attached as an example in the appendices. MasterData-element can be found in appendix F and it is used to register new load control targets or relevant changes in the information related to the load control target.

The information exchange related to load control process includes also confirmation messages about if the wished control could be executed or not. Also, when concluding a load control contract the customer wishes to keep the last right to accept the control or not. Therefore, one control message from the supplier to the DSO is not enough and the reply message from DSO to the supplier indicates the actual effect. Most of the load control requests are delivered with state information (on/off) but there is also a reservation to use dynamic load control with power decrease (or increase) in the messages (Tervo & al. 2014).

There exists a question if two-way information about the status of customer's loads is needed. The load control request can be successfully passed to the customer's relay but the supplier will not know the actual effect of the control if the customer's load happens to be already off. With the present AMR metering infrastructure it is probably impossible to identify the amount of the cut load. However, depending on the type of the load and the additional information of Z03 message showed in table 6.3 the status of the load can be rather well forecasted. Building a two-way data transfer to inform the actual status of customer's loads might become too expensive compared to the reached benefits.

When the datahub will be taken in use the load control requests could go also through that. The functionality may not be included in the first version of the datahub but in the second version it can be possible. There could be saved the planned control table for a usage place for the coming day. Also the reply information about executing the controls could stay in datahub. In the time series the DSO passes to the supplier need to be an information field for load control for the hours.

In present model, when transmitting time series for billing, the DSO confirms for the supplier the real reason for billing, actual or estimated, in message Z11. The supplier gets all the meter readings and possible changes in annual consumption estimates based on the reading. Z11[5] informs the actual metering data for consumption-based invoicing during supply. In the same message need to be applied information about if the DSO executed load control during that hour or not. The alternatives for the information status is introduced in table 6.4.

***Table 6.4**. Additional information in Z11 message.*

| **Hour included:** |
| --- |
| Load control based on supplier's request, request executed |
| Load control based on supplier's request, request denied by customer |
| Load control based on supplier's request, transmitting failure |
| Load control based on DSO's need |
| No load control |

Based on the control state information of Z11 message or to the data transfer between the supplier's own HEMS and information system can be calculated how many hours during a day or another time span the control has been used. The control times need to be calculated and saved in the information system so that times will not exceed the agreed amount and so that the bill will generate right if there is agreement about compensation per control times. There need to be a usage place specific counter that counts the states "Load control based on supplier's request, request executed" into the supplier's metering data system.

The number of the controls from the counter might be used when generating the bill for the customer. Even if the customer will not get any time-based compensation for the controlled hours it can be an interesting fact to write on the bill how many times the supplier used it's right to control electricity usage. At least the control data will be shown in the customer web portal.

### 6.3.3 Control groups

When concluding the load control contract it needs to be decided which loads can be controlled, on which conditions and with what kind of compensation. For the supplier it is easiest to offer a few alternatives from which the customer can choose what the most suitable groups are for him. If the supplier has for example five different control groups for customers, the groups can be used differently based on the load types. For example, one group can be only used to offer consumption decrease to reserve market and others to spot market. The first step for the supplier seems to be to offer one or two alternatives for load control contract. The customer can evaluate if the contract is suitable for his usage place or not.

As discussed in chapter *4.4 Load control*, the reserving electric heating is the easiest load to control because it has relatively big capacity and high flexibility potential compared to smaller household appliances. This kind of heat storages are the easiest way to “store electricity” nowadays. Furthermore, for example the need for hair dryers and car heating is strictly bound to time.

Besides the electric heating i.a. ventilation, own energy production and possible batteries are interesting loads for the supplier. The customer could be able to inform the supplier about his loads when making the electricity contract, and also update the information in a web portal when needed. At some point the collected information about available loads can be valuable to the supplier even though it does not control them all with the present electricity contract.

Households with reserving electric heating have typically already one kind of DR contract since the houses are warmed up with night-time electricity. The loads are connected to a relay that switches them on when the night-time tariff begins. The load capacity of reserving electric heating is kind of used already but the arrangement still leaves flexibility potential during night-time. Therefore, the reserving electric heating would be also in the future one control group for the supplier.

Households with direct electric heating have also a huge capacity for load control. Their flexibility potential is not that great but they could be used as another control group. That group would be most beneficial when using their flexibility potential in reserve market or balancing power market.

Freezers and refrigerators are one potential control group since every household has those and they are always running. Nevertheless, they divide opinions as a control group because customers are suspicious that the temperature will decrease too low. They can be safely switched off for an hour without any harm to the food. They are though maybe not the best group to switch on and off several times per day but that group could be switched off during the most expensive price peaks and also occasionally for reserve market. Despite the good availability of the flexibility the cooling appliances are not the best group to utilize DR first, because modern freezers and refrigerators consume relatively little energy.

Other appliances in a household are usually thermostat controlled or usually off so they might not be the first groups that the supplier will ask to control. Possible device groups for load control are visualized in figure 6.4. The brighter the ellipse is the better the availability of the group is, because the loads are more often on. The size of the ellipse describes potential capacity. The ellipse size of electric cars is scaled to represent the situation when electric cars more common.

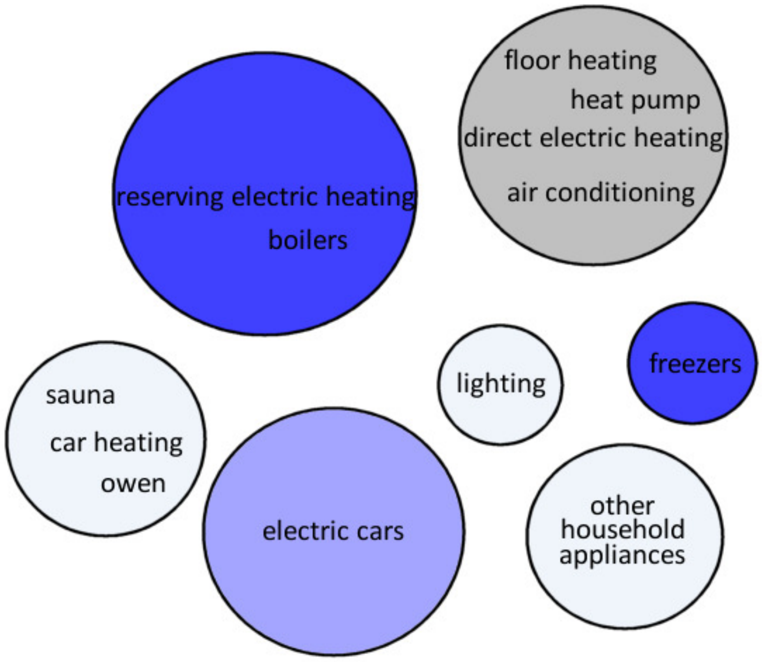


***Figure 6.4**. Household load types and their roughly estimated power and usability for load control.*

If the supplier wishes to build control groups of devices presented in table 6.5 the supplier can let the customer to choose all the devices he wants and the contract will be generated based on those choices. Alternatives for choosing the contract suitable for a customer was discussed also in SGEM report D 4.6.9 *Study of pricing process flows and connection of control processes* (Joensuu & al. 2012).

First publicly available load control contract possibly has only one or two choices that the customer can make. The alternatives could be reserving electric heating and direct electric heating. After that the customer needs to inform the power of his heating system. One question is that is it fair if all the customers will get as much discount as everyone else if the capacity of their loads are significantly higher or lower as the average. Therefore, it would be beneficial to divide the loads in size categories and the discount depends on the category. Summarized, the minimum viable product for an electricity contract including load control could only consist of controlled heating.

## 6.4 Improving the customer relationship

After the electricity contract is concluded shall the customer not be forgot. The aim is to keep the customer satisfied because a satisfied customer is usually loyal and has no need to switch his supplier. Nowadays the power of an individual is higher than ever because of social media. Therefore it is even more important to please the customer to keep a positive supplier brand. The supplier can stay close to customer thanks to internet which is inseparable part of people's lives. Because of huge amount of available information the consumers are critical and the user interface and openness has become important factors in providing any service or product.

### 6.4.1 Additional value in demand response products

Customers are not willing to buy anything which value they do not understand. Therefore, the end-users need to get introduced to electricity market and why the price for electricity changes by hour. Nowadays, the wide mass claims to be interested in energy saving and green energy but usually they are not ready to pay any higher price for the same kWh produced by neighbor's solar panels. The customers appreciate cheap energy over any advanced energy portal or electricity contract that invests on seal protection. The best way to get customers interested about DR is to show the financial saving that DR can bring to them. In any case, when offering DR contracts the symbolic price of the incentive is valuable.

Moving into consumption based invoicing has increased customers understanding about formation of the electricity bill. If dynamic pricing and load control with its compensation is added to the bill becomes the situation again more complicated. If supplier centric model was taken in use it would ease the situation. If the supplier would invoice the electricity distribution together with the energy sale it would strengthen the supplier's relationship with the customer. The supplier would be seen more as a service provider and the DSO more as an authority who will be contacted in special occasion like in case of blackout or construction.

The supplier can promote its business by providing information about electricity usage. If the supplier offers information and services for example for small-scale electricity production, will it profile the supplier as a reliable service provider. That helps to get the customer interested to conclude a load control contract with that supplier. Advertisement for tempting new customers to conclude an electricity contract can be disguised in electricity market advisory.

If a supplier offers practical guidance for own electricity production achieves the supplier a good chance to sell a HEMS together with the load control contract for customers. For example, a supplier could offer free guidance for own electricity production for those buying or building a house. Those potential customers have probably used their all construction budget but they would be interested in solar panels some years later. There the supplier could sell them a HEMS together with a load control electricity contract and guarantee that the HEMS can easily be extended with own production, electric car or batteries. If a supplier makes a deal with a device manufacturer the marketing of energy solutions together with an electricity contract can benefit both partners. The figure 6.5 shows marketing example of a combined product that supplier could offer beside solar panels and HEMS-boxes.

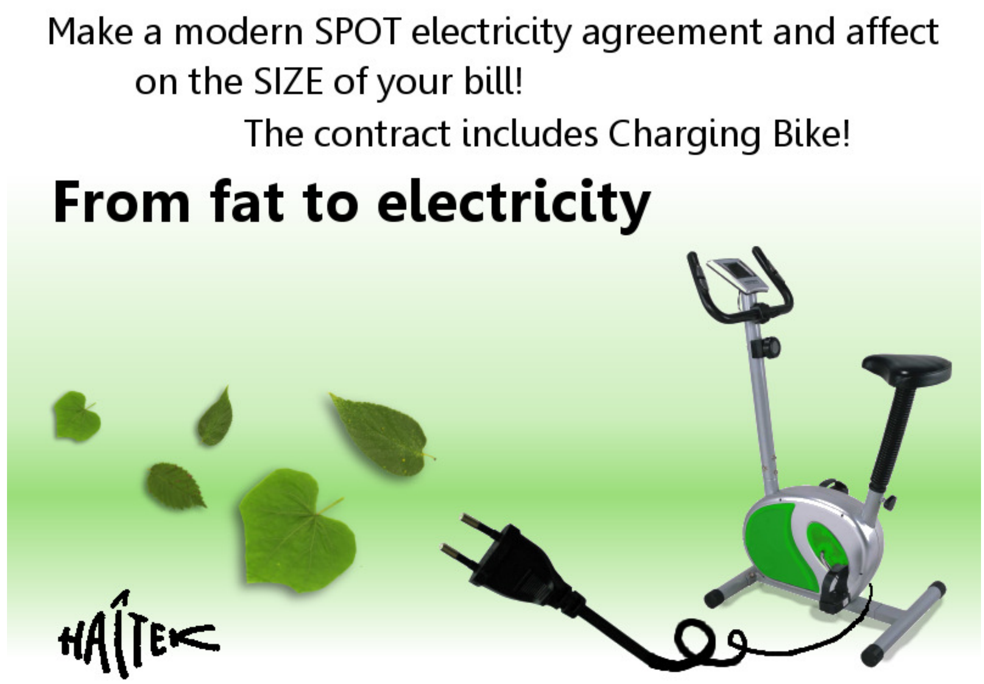


***Figure 6.5****. Author's vision how to advertise dynamic electricity contracts and get consumers' attention. (Original bike from China Trade Gateway 2014)*

A supplier could pack for a customer a turnkey home energy solution including electricity contract, energy consultancy and personalized device packet. A customer could choose into his packet a HEMS, heating solution, solar panels, wind mill, regenerative exercise bike, batteries and even an electric car. If leasing batteries were included to supplier's assortment could the supplier benefit from the battery capacity if it had a control over the batteries with a DR electricity contract. An overall energy solution offered by one service provider would be valuable also for the customer. If a there is only one customer interface, the service provider cannot avoid responsibility in case of problem situations.

A well designed user interface in the HEMS will bring extra value to the customer because the savings and energy usage will be easily seen. The customers are more interested in following saved euros than unused kilowatts. This is a good starting point for a HEMS with DR contract since the main issue is not saving energy but using the same energy cheaper. One significant information brought by HEMS can be showing device specific consumption. That can indicate to the customer if an old household appliance is using surprisingly much energy and might be more profitable to be replaced. The customer can also follow how much his electricity bill will decrease if he lowers the room temperature by one degree for a week. The HEMS or a customer energy portal will also show how much the customer saved when letting the supplier to control his loads. However, the value of following the consumption shall not be overestimated because the customers are lazy to look at any diagrams if it needs even one click.

When offering to the customers a possibility to follow their device specific consumption and its history it will bring valuable information for the supplier as well. The supplier can collect much more information about customer's actions. That big data can be analyzed and used to forecast the behavior of active customers to improve the balance in electricity procurement when the amount of spot priced electricity contracts will become more common. For example, logged data about usage of certain group and denied load control requests help to estimate the comfort requirements of different customer groups. This is important to estimate the flexibility potential of different load control groups.

The electricity market is an imperfect market because there consumption hardly is flexible with the price of the commodity. For example, the consumers are used to drive to the service station when and where the price for gasoline is low. The consumers need to change their attitude to be more flexible with electricity usage as well. The customers prefer not to think about electricity contract that much but changing supplier should become as easy and understandable as changing mobile phone contract. People are interested in making mobile phone deals that include both the phone and the connection and the contract period is typically two years. The same model could work with electricity contract including HEMS for load control or offering some other additional value beside the electricity sale.

### 6.4.2 Case Mikontalo

The students can be used as test rabbits to find out how living goes with load control. Students are flexible, adaptable, they appreciate green values and they like to be pioneers on many fields. Students also like the situation where electricity is included to the rent. Because those students living in student apartments do not have own electricity contracts the student housing association can conclude an agreement with electricity supplier who lets the supplier control the electricity usage of the student house.

This last chapter gives an example how load control can be implemented in a block house where the consumption of a single apartment is relatively low. A student house Mikontalo in Tampere with its 288 apartments is taken as an example case to demonstrate the setup. If the following demonstration would be implemented in Mikontalo the achieved attention in media would be the most valuable issue in that project. The customers' understanding about electricity market is really narrow, so the wide mass does not understand the need for DR and load control. To get people familiar with DR they need to understand that the price of the electricity varies per hour. Writing about DR in the media would be important because nowadays the power of the media to the people is huge.

The key idea in the case Mikontalo is gamification and the game is called ElectroLab. In the case the residents will compete against their neighbors and try to make their electricity bill as low as possible. The electricity usage is invoiced based on the spot price and the residents will carry out DR by themselves because it is beneficial to adjust own electricity usage on the cheaper hours to succeed in the game. As a reward for succeeding in the game the landlord can give discount in the rent, some other incentives like gift cards or unlock new features in the game.

ElectroLab utilizes human's neighbor envy and competition instinct. The game has a mobile and web portal and the residents will be ranked in there based on their electricity consumption. To ensure the privacy of the residents the ranking list will only show nicknames of the residents. Besides spot priced electricity usage some load controls will be also used in Mikontalo. The sauna and the laundry room will be unavailable when the spot price for electricity goes for example over 8 c/kWh. Among Nord Pool Spot, Elspot FIN was only 36 hours over 8 c/kWh within gone year (10.11.2013-10.11.2014) so the restriction is not terrific. Additionally, to the gym of Mikontalo will be brought regenerative exercise bicycles and rowing machines where the residents can generate electricity to improve their personal electricity balance.

To catch attention in the media the implementation shall use also blackouts as last control action in Mikontalo. For example, the landlord can define that electricity budget for any hour shall not go over 20 euros. Let's assume that during a peak hour the average consumption in an apartment is 1 kW, which makes with the 288 apartments together 288 kW during that hour. With spot price of 80 €/MWh the cost for the hour would become 25,92 € that exceeds the budget. In this case the consumption would be automatically restricted for nearly 14 minutes. Because the price for the hour is known beforehand the residents can be warned and they can prepare or even prevent the blackout.

***Table 6.6.*** *Example cases of the load control effects of high spot hour.*

| **apart-ments** | **average consumption /apartment, kW** | **price, €/kWh** | **budget, €** | **price without restriction €/h** | **restricted time or power** |
|---|---|---|---|---|---|
| 288 | 0,5 | 0,1 | 15 | 14,4 | 0 |
| 288 | 1 | 0,1 | 20 | 28,8 | 30,6 % |
| 288 | 1,5 | 0,08 | 25 | 34,56 | 27,7 % |
| 288 | 1 | 0,08 | 25 | 23,04 | 0 |
| 288 | 2 | 0,045 | 25 | 25,92 | 3,5 % |

To follow the actions of the residents and log the produced and consumed energy the residents will have an identification key integrated to their home key. ElectroLab application will bring additional value to the resident because it will build statistics about the usage of elevator and the hours spent in the gym based on the logged data of the ID key. The mobile application will notify the residents about high spot hours and the restriction of the electricity in the house. For example, the user can check from the application if his roommate is at home or not based on the real time consumption data. Furthermore, the application will give information about the device specific consumption if socket specific metering is available.

Beside cheaper electricity bill, for the landlord the gamification will bring additional value by getting more information about the movements of the residents. It will also brighten the brand as an environment friendly forerunner company.

The figure 6.6 shows how the user interface of ElectroLab would look like. There the coloring of own electricity usage indicates if the reading is low or high compared to neighbors. Own consumption can be also compared to consumption of the floor, the stair-step or the whole house on different time spans.

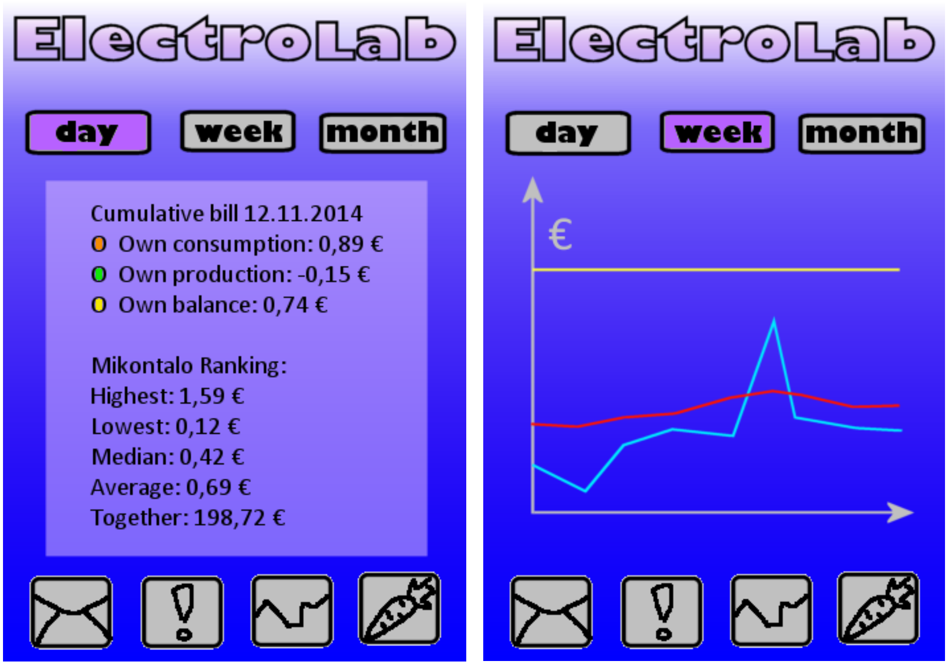


***Figure 6.6***. *View examples from the DR game mobile application.*

In Mikontalo is living mostly technical students so it is a perfect group to get constructive customer feedback and maybe innovative developing ideas. Of course, this kind of implementation is economically most beneficial to execute in a block house in the planning and building phase. Luckily, there is demand for new student apartments all the time. Besides student housing, modified version of this gamification can be used also in i.a. assisted living buildings and private row or block houses.

# 7. CONCLUSION

Demand response has an important role in creating flexibility in future's smart grid. With price-based demand response (DR) consumption will drift to those moments when the price for electricity is low and there is more production. DR is the solution to take advantage of increasingly more renewable energy production that varies greatly by season, day and hour. This study researched the effects of electricity contracts enabling DR in the interface of electricity supplier and customer.

The framework for DR is challenging since it involves several parties. The present market parties regard that DR is "no one's business". Therefore, common guidelines are needed into the legislation to proceed co-operation of parties with different expectations. An expansion about DR to *Guideline for AMR metering* or *Terms of electricity sales* could help the situation. In general opinion, supplier should be the party to implement DR and DSO the party to provide the technical equipment. Understandably, the interviewees waited from the DSOs as ready platform to utilize DR as possible. The supplier has been seen the best party to implement DR because it can achieve highest profit optimization when pushing customers to change their hourly consumption. Additionally, when supplier is the one making the decision to use load control on a particular hour it can benefit the whole market area. That way DR can be included already to the price formation process of the day-ahead market place in wholesale market.

In Finland, need for DR raises slowly since the electricity is comparatively inexpensive in here. However, DR need to be taken in account in construction and legislation to be easily adopted in the future when the volatility of electricity price increases. This far, customers have concluded the electricity contract with the supplier who sells the electricity with cheapest price because electricity is the commodity that comes from the socket. The image about electricity and electricity contracts should be changed. The supplier could be a service provider who offers energy solutions for a customer and brings additional value to his life.

To find potential customers for DR the consumers need to become more aware about formation of electricity price. The power of media can be used to communicate the consumers the mechanism of electricity market and the effects of intermittent energy production. Overall, consumers are interested in green energy production and smart housing. Finnish Housing Fair would be perfect place to present how load control fits in households. After the idea of load control is introduced to consumers they can give better feedback about it. At this point, the interviewees could not say how much a reasonable compensation is if the supplier has the right to manage customers' electricity usage. The suppliers preferred to base the compensation on the times of controls but it might not be the most pleasant alternative for the customers because they could not estimate the size of their next electricity bill.

The interviewees stated that the best load for load control among households is electric heating. The first load control contracts are probably only controlling of heating. When interest towards other controllable loads rises, diverse load control is better to implement in new electricity usage places, because changing the coupling afterwards at home is more expensive than the saving potential. A good opportunity to implement wide-scale load control is along the changing into new generation electricity meters. The present trend in building technology is strong insulation of houses, which lowers the energy consumption and need for heating. Luckily, that makes electric heating a cost-effective heating solution.

Marketing of DR contracts for suitable customers includes risks and needs capital. The interviewees were suspicious about customers' interest towards a home energy management system (HEMS) that brings only extra costs for them. The potential group of engineers and pioneers interested in DR is marginal, and the general opinion of interviewees were that customers prefer cheap electricity price over any possibility to follow own energy consumption. If the interviewees had been representing the biggest energy companies with bigger marketing budget the answers might have been different. The competition in electricity sale increases in common electricity market and DR can be used as competitive advance if the mission of the supplier is to gather more customers.

The interface of supplier and the customer and the whole business of energy market need reform. DR and load control cannot be presented for all the customers with home automation device that can bring them 50 cent of saving every time the supplier uses its right to control customer's loads. A consumption display is usually not the value that the consumers appreciate. Furthermore, discount in the bill is not the best incentive for all customers because growing share of people prefers downshifting to counting euros. All consumers do not particularly care about the size of electricity bill because the electricity is not expensive enough in Finland.

Considering the present fitness trend the people are most interested in living healthy. A whole new incentive to be more flexible with the consumption could be e.g. a regenerative exercise bike or gamification. Also, with an exceptional offering the attention in media would be the most valuable achievement for the supplier and for the whole electricity sale business. That would help the consumers to think about and approve new kind of electricity contracts. However, it can be concluded that the compensation for load control need further research among the customers.

Today DR can be carried out with dynamic electricity contracts and they can be used to present the idea of DR to the customers. However, the growing share of dynamically priced electricity contracts and active customers increase supplier's risks. The usage of electricity is important to forecast beforehand to optimize supplier's electricity procurement. There would be demand for new models to estimate the impact of dynamic electricity price to consumer behavior. The change in consumer electricity usage behavior would need further research to make dynamic electricity contracts desirable for both the supplier and the customer.

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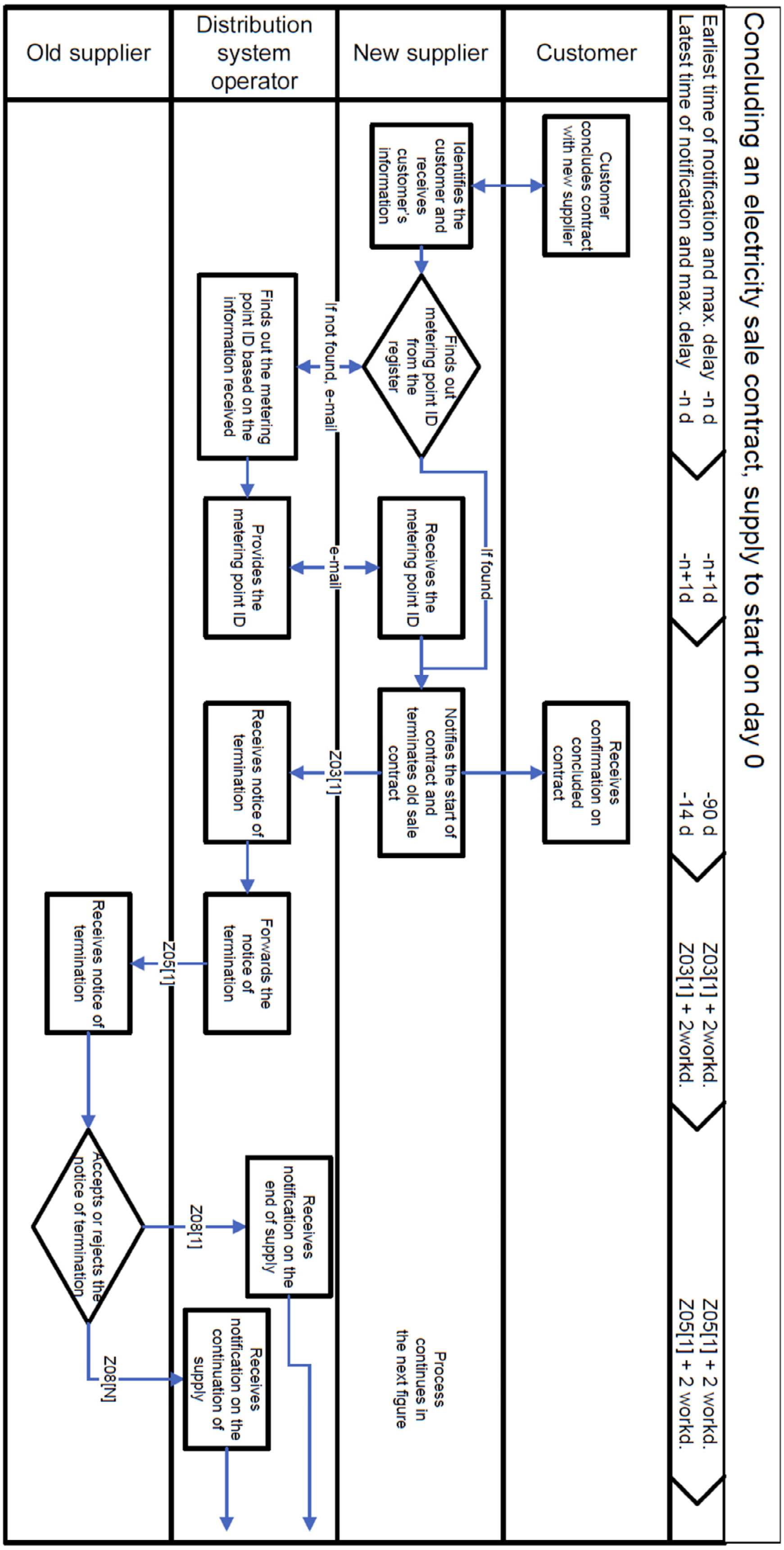
## APPENDIX A: INFORMATION IN THE MESSAGE Z03

| Message Z03 | Use case<br>14 Movement In | Attribute | Field | length | type | Example | Comment,<br>Extra info |
|---|---|---|---|---|---|---|---|
| **Use case id** | **14** | | 8:LIN:1229 | 2 | an | 14 | |
| Use case reference | **P** | 16:RFF:1153:AIV | 16:RFF:1154 | 35 | an | 2006092112346 | |
| Street address of metering point | **P** | 17:NAD:3035:IT | 17:NAD:3042 | 35 | an | Kauppakatu 10 B 24 | |
| Post code | **P** | 17:NAD:3035:IT | 17:NAD:3251 | 6 | an | 00101 | |
| Post Office | **P** | 17:NAD:3035:IT | 17:NAD:3164 | 35 | an | Helsinki | |
| New supplier id | **P** | 4:NAD:FR | 4:NAD:3039 | 6 | an | OSM | |
| Contract number of new supplier | **P** | 16:RFF:1153:VC | 16:RFF:1154 | 12 | an | 100256 | |
| Country code | **P** | | | 2 | an | FI | |
| Net area code | **P** | 4:NAD:3035:DO | 4:NAD:3039 | 6 | an | HKE000 | |
| Metering point id | **P** | | 8:LIN:7140 | 15 | an | 83625 | local id |
| Proposed begin of supply date | **P** | 8:DTM:2005:92 | 8:DTM:2380 | 12 | n | 200608010000 | |
| Measurement type id | v | 14:CAV:7111:ZZZ | 14:CAV:7110 | 8 | an | 2 | 14:CCI:6313:Z16 |
| Consumer profile id | v | 14:CAV:7111:Z01 | 14:CAV:7110 | 4 | n | 3 | 14:CCI:6313:Z04 |
| Invoicing mode | **P** | 14:CAV:7111:ZIV | 14:CAV:7110 | 2 | n | 1 | 14:CCI:6313:ZZ1 |
| Name of new customer | **P** | 17:NAD:3035:UD | 17:NAD:3036 | 35 | an | Meikäläinen Matti | It is recommended to write last name before first names. |
| Personal Id/company Id of new customer | **P** | 17:NAD:3035:UD | 17:NAD:3039 | 13 | an | 010145-123A | Official writing form is recommended (capital letters) |
| Street address of new customer | t | 17:NAD:3035:UD | 17:NAD:3042 | 35 | an | Oikokatu 23 A 4 | |
| Postcode of new customer | t | 17:NAD:3035:UD | 17:NAD:3251 | 6 | an | 00120 | |
| City of new customer | t | 17:NAD:3035:UD | 17:NAD:3164 | 35 | an | Helsinki 12 | |
| Name of invoicing customer | t | 17:NAD:3035:IV | 17:NAD:3036 | 35 | an | Meikäläinen Oy | It is recommended to write last name before first names. |
| Invoice's street address | t | 17:NAD:3035:IV | 17:NAD:3042 | 35 | an | PL 123 | |
| Invoice's Postcode | t | 17:NAD:3035:IV | 17:NAD:3251 | 6 | an | 01234 | |
| Invoice's City | t | 17:NAD:3035:IV | 17:NAD:3164 | 35 | an | Laskunet | |
| Billing type | **P** | 14:CAV:7111:ZBT | 14:CAV:7110 | 2 | n | 1 | 14:CCI:6313:ZSS |
| Contact person | t* | 18:CTA:3139:IC | 18:CTA:3412 | 35 | an | | |
| Telephone number | v | 18:COM:3155:TE | 18:COM:3148 | 25 | an | 123456789 | 18:CTA:3139:IC |
| Name of new customer 2 | v | 17:NAD:3035:ZU2 | 17:NAD:3036 | 35 | an | Esimerkki Erkki | It is recommended to write last name before first names. |
| Personal Id/company Id of new customer 2 | v | 17:NAD:3035:ZU2 | 17:NAD:3039 | 13 | an | 311244-987A | |

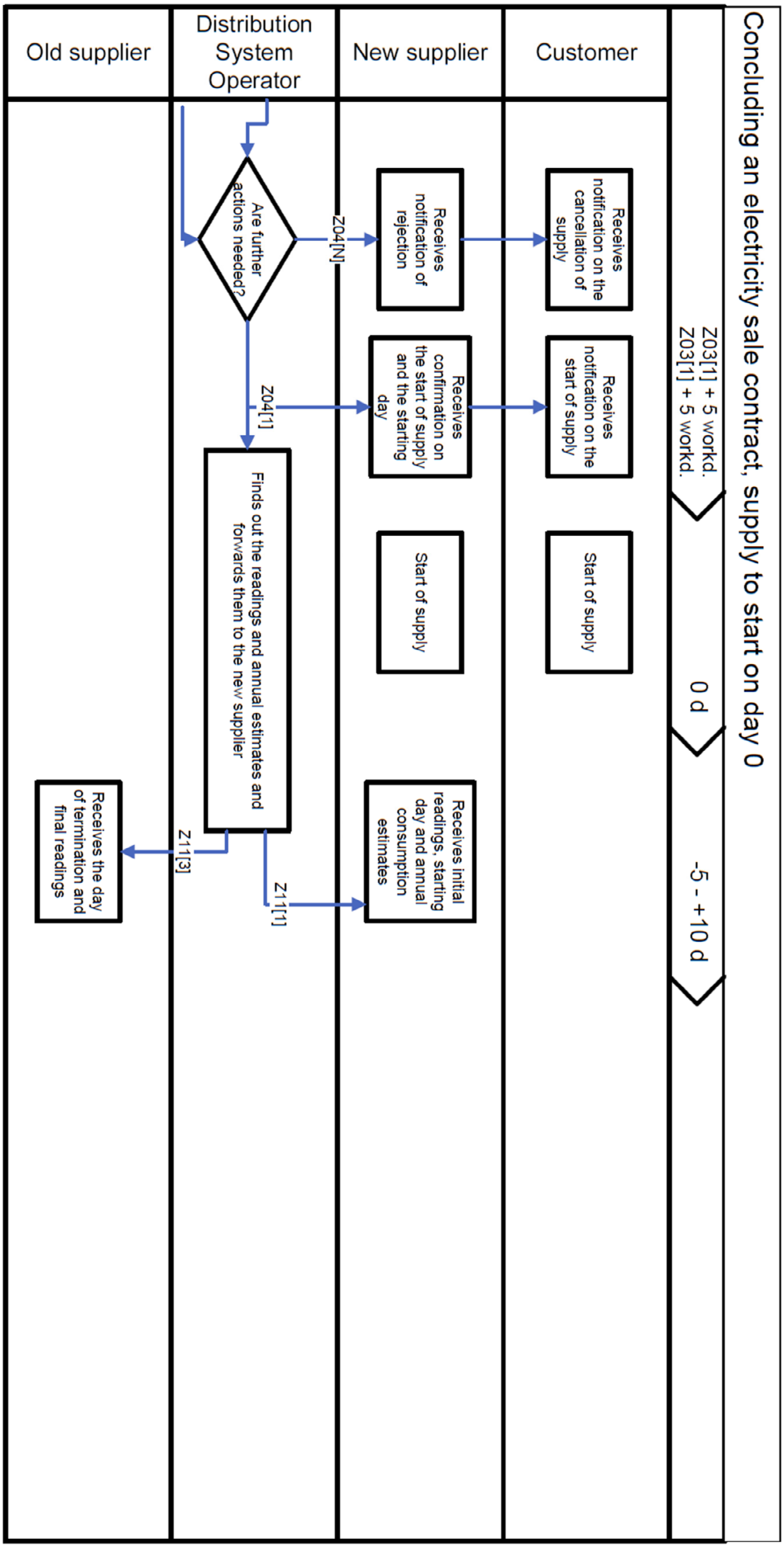
**P=obligatory**
t=dependant
v=optional

* obligatory if *Telephone number* in use

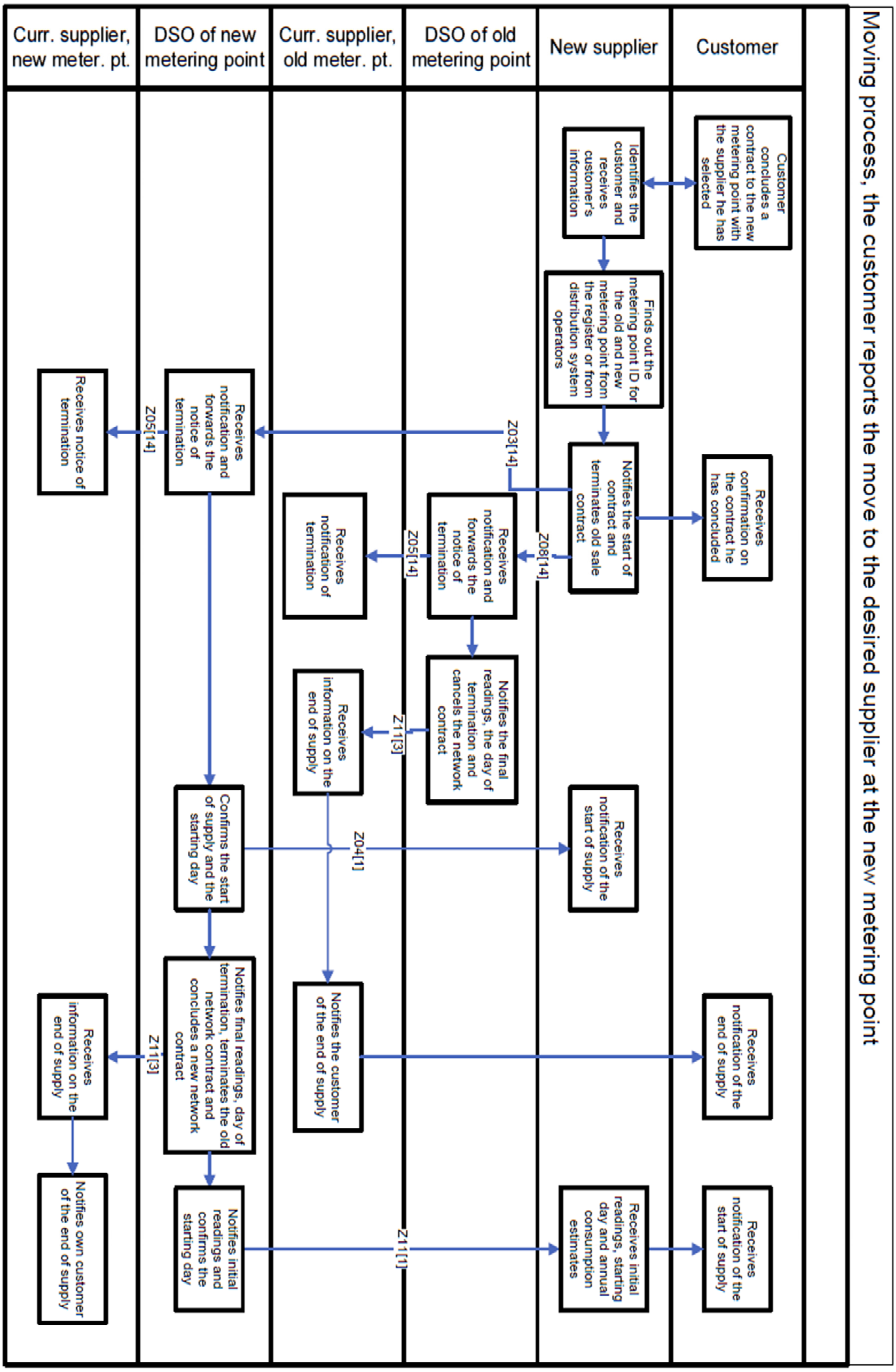
# APPENDIX B: PROCESS OF CONTRACT CONCLUSION (1/2)



# APPENDIX B: PROCESS OF CONTRACT CONCLUSION (2/2)



# APPENDIX C: MOVING PROCESS



# APPENDIX D: HAASTATTELU KYSYNTÄJOUSTOSTA

YLEISTÄ

Kuinka monella asiakkaallanne on tuntihinnoiteltu sähkösopimus?

Ovatko asiakkaat antaneet siitä palautetta?

Paljonko sähkön hinnan pitäisi kallistua, jotta alkaisitte tarjota kysyntäjouston mahdollistavia sähkösopimuksia? Tai oletteko muuten suunnitelleet uusia sopimusrakenteita?

Minkälaisia sähkösopimuksenne ovat nyt?

Ostatteko pientuotantoa? Miten asiakkaiden pientuotanto työllistää yhtiötänne?

NÄKEMYKSET LIIKETOIMINNASTA

Miten kiinnostavana näette kysyntäjouston liiketoiminnassanne? (Esim. sähkönhankinta spot-markkinoilta, kulutustaseen hallinta?)

Näettekö että kysyntäjousto olisi jatkossa yksi valttikortti sähkönmyyjille uusien asiakkaiden hankinnassa ja liiketoiminnan laajentamisessa?

Miten suhtaudutte myyjäkeskeiseen markkinamalliin?

KUORMANOHJAUS

Miten saisitte suurimman hyödyn asiakkaiden kuormien ohjauksesta? Millä aikajänteellä kuormanohjaus voisi yleistyä asiakkaidenne keskuudessa?

Mitä uutta tietoa tarvitsisi kerätä asiakkailta sähkösopimuksen yhteydessä, jos sovitaan kuormanohjauksesta?

Vaatisiko kuormanohjaus suuria muutoksia asiakastietojärjestelmään ja laskutukseen?

Olisiko asiakaslähtöinen ja hintaperusteinen kuormanohjaus vai myyjän toteuttama suora kuormanohjaus parempi ratkaisu? Huomioi toteutusten helppous verrattuna hyötyyn.

Mikä olisi asiakkaille paras kannustin myyjän tekemään kuormanohjaukseen? (Esim. puolet halvempi kuukausimaksu sähkösopimukselle?)

Tiedottaminen hintapiikeistä: Mitä luulette, välttäisikö valveutuneet asiakkaat vapaaehtoisesti kulutusta huipputunteina?

Näettekö kuormanohjauksen käytännön toteutuksessa ristiriitoja myyntiyhtiön ja jakeluverkkoyhtiön välillä?

# APPENDIX E: INTERVIEW ABOUT DEMAND RESPONSE

GENERAL

How many of your customers have an hourly priced electricity contract?

Have the customers given feedback about it?

How much more expensive electricity should become that you would offer electricity contracts utilizing demand response? Or have you planned new contract structures?

What kind of electricity contracts are you offering now?

Are you buying small-scale production? How busy does customers' own production keep your company?

VIEW ON THE BUSINESS

How interesting you regard demand response in your business? (E.g. electricity procurement from spot market, balance management?)

Do you see that demand response could be an advantage for electricity suppliers in customer acquisition and broadening the business?

How do you regard the supplier centric model?

LOAD CONTROL

How would you benefit the most by controlling your customers' loads? In what time span the load control could become common among your customers?

What kind of new information should be collected from the customers when concluding an electricity contract if about load control will be agreed?

Would the load control require great changes in your information system and invoicing?

Which one do you regard as better option, customer-oriented price based load control or load control made by the supplier? Consider both the easiness and the benefit of the implementations.

What would be the best incentive for load control made by the supplier? (E.g. monthly fee of the electricity contract for half price?)

What do you think, would the aware customers avoid electricity usage voluntary during on-peak hours if they were informed about the price peaks?

Do you see contradictions between a supplier and a DSO in practical implementation of demand response?

# APPENDIX F: TARGET INFORMATION IN LOAD CONTROL MESSAGE

| Element | Type | Mandatory (Y/N) | | Repe-tition | Description |
|---|---|---|---|---|---|
| | | Requ-est | Res-ponse | | |
| Network | String | Y | Y | 1 | Identifier for the distribution network. |
| SupplierID | String | Y | Y | 1 | Identifier for the electricity supplier. |
| GroupID | String | N | N | 1 | Identifier for the target (load control group). |
| .ServiceDelivery Points | String | N | N | 1 | Defines the controllable targets whose basic information is included to the message. |
| ..ServiceDeli-very Point | String | N | N | 1.. n | Defines a single controllable target. |
| ..PointID | String | N | N | 1 | Consumption place ID. |
| ..Status | String | - | N | 1 | Availability of the target. |
| ..TargetType | String | - | N | 1 | Type of the controllable target (Boiler, FloorHeating,…) |
| ..Unit | String | - | N | 1 | Power unit for the controllable target. Default = kWh. |
| ..Priority | String | - | N | 1 | Reservation for the priority infor-mation of the control target. This can be used to indicate that there are some specific limitations of how the target can be controlled. |
| ..LoadCount | String | - | N | 1 | Number of the separate controllable loads in the target. |
| ..NominalPower | String | - | N | 1 | Total nominal power of the loads included in the load control target. |
| ..NetworkTariff | String | - | N | 1 | Distribution tariff of the load control target. |